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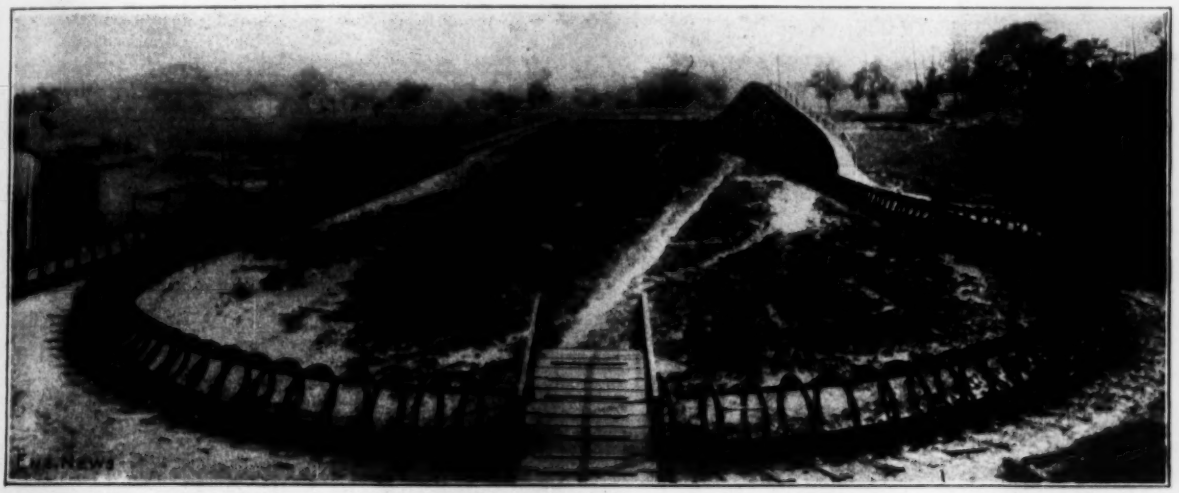
Electric Carrier Railways for Rapid Transfer of Mail and Express

For many years the need has been recognized of ample facilities for the rapid transportation of mail and light express matter between the distant parts of a large city, and for such service the pneumatic-tube carrier has been developed to what now seems a probable limit of size and capacity. For small mail-transfer systems, the pneumatic tube presents many obvious advantages on account of its simplicity, while the inefficiency of compressed-air power is not important. Tubes as large as 18 in. in diameter have been made, experimentally at least, and one such is reported installed in Washington, D. C., but not in general use because of noise and clumsiness. When systems requiring tubes of over 12 in. become necessary, then the cost of power supply becomes a more important factor; at the same time the employment of electric motor-driven cars becomes more advantageous than before on various practical grounds.



ELECTRIC-CARRIER RAILWAY EXPERIMENTAL PLANT AT PATERSON, N. J.
(Showing tangents, two 40-ft. radius curves, 20% grade and steel tube.)

As the increasing need for good facilities for the transfer of mail and light freight has continued to be felt, the problem has been studied by various interested concerns with the result that where larger tubes are needed the manifest tendency is toward the use of motor cars operating in tubes of two to four feet diameter. Two systems of this sort have now been built on a commercial scale, as shown in the appended descriptions.

The general scheme is old. One of the earliest notable propositions of the sort was put forward by D. G. Weems, who, 24 years ago, had a two-mile experimental "high-speed" railway line in operation near Baltimore, Md. The Weems road had a 24-in. gage track and a 6000-lb. three-car train. There was an electric locomotive unit some $2\frac{1}{2}$x$3\frac{1}{2}$ ft. in cross-section and 18 ft. long, with pointed ends. The promoters hoped to run "mail trains" at speeds of four or five miles a minute over long distances as from New York to Chicago (see ENGINEERING NEWS, Sept. 14, 1889). Weems was in advance of his time; but similar projects for high-speed mail transmission by an electric carrier railway many times have been agitated since.

Perhaps the greatest recent incentive to the development of these systems has been the desire of the U. S. Post Office Department to have a practicable plan worked out of large tubes for carrying mail between the different stations in New York City. The present 8-in. pneumatic tubes, of course, do not permit of direct transfer of regulation mail sacks. It is necessary to unpack the train pouches and reload the bundles of letters into the tube cartridges. The Department desires an automatic system of large capacity, both in regard to size of sacks which can be carried and the rapidity with which cars can be dispatched.

The extreme speed sought by the early promoters of such schemes is now seen to be of less importance than ability accurately to maintain a small interval between cars under speeds of 15 to 30 mi. per hr., and to give a low-unit cost of burden transported. The service of such a carrier system is seen to bear some resemblance to miniature trunk-line railroad operation, but under conditions which are favorable to automatic operation of cars (without motormen) equipped with constant-speed motors. There are no stops between terminals and acceleration problems are simplified since bulk rather than weight limits the capacity of a car. The constant-speed

motors may be either (1) a shunt-wound direct-current type taking current off feeders of approximately constant voltage or (2) an alternating-current induction motor drawing energy from feeders connected to constant-frequency supply (which may fluctuate more or less in voltage without affecting the speed). With either equipment, cars can be sent safely in the same direction over one track not very far apart giving ability to dispatch them as rapidly as they can be loaded at one end or unloaded at the other. They should maintain their spacing approximately, but should one car crawl up on another, by reason of unequal drive-wheel slip, etc., there would be no real collision at such small differences in speeds as would exist; the pursuing car, after contact, would assume some of the traction load of the one leading and they would proceed together as a train. The two systems described in what follows illustrate the two uses of motors above noted, with some very interesting modifications in the case of the alternating-current motor to decrease and more accurately to maintain the intervals between cars.

FIG. 2. VIEW OF ELECTRIC-CARRIER EXPERIMENTAL YARD, SHOWING LOADING TRACKS, LABORATORY, ETC.
(Taken from trestle seen in Fig. 1.)

The direct-current carrier railway mentioned has been developed by the American Pneumatic Service Co., of Boston, Mass., which concern has developed the successful large pneumatic-tube systems used by the Post Office Department in Boston, New York, Chicago and St. Louis. The alternating-current system is that of the Electric Carrier Co., of New York City.

(1) THE TUBE RAILWAY OF THE ELECTRIC CARRIER CO.

Several years ago the simple idea of having an induction motor drive a carrier car was modified by one F. S. Smith, who patented the proposal virtually to unfold the two parts of an induction motor, placing the primary element flat on the bottom of the motor car and stretching out flat a long secondary element in the center of the running track. The result of this arrangement may be seen from the action of the ordinary induction motor, where the imposition of polyphase currents on the primary (stationary) windings causes the polarity of the magnetic field to revolve. This induces currents in a brass or copper annular grid, placed in the face of the iron core of the rotor. The reaction of the magnetic field and the currents in the grid causes the rotor to be dragged along close behind the revolving magnetic field and at a speed only slightly less than synchronous. In the case of the modified system, the imposition of the polyphase currents on the straightened-out primary circuit, disposed along the car parallel to and close to the secondary elements which are fastened to the track, results in the magnetic poles of this field progressively moving from the front to the back of the car. This induces currents in the grids of the secondary element, and the reaction tends to pull the track structure after the shifting primary field. But as the track is fastened, relative motion occurs by drawing the car forward.

One advantage claimed for this arrangement is that dependence on adhesion conditions for traction is eliminated, irrespective of grade. Then too, the moving parts of a motor, as ordinarily built, are eliminated, and, with them, the wear and inefficiency in traction gearing. There should be expected also less heating of the propelling machinery of the car than with ordinary arrangements, since only one-half the motor element is fastened thereto and both parts are arranged in a form adapted to obtain maximum cooling effect.

By changing the material and design of the grid on the secondary element, disposed along the track, the tractive effort of the car may be varied from place to place to suit the requirements of starting grade, etc., within certain limits. Any great change in the characteristics of the secondary circuit of an ordinary induction motor on an automatic car, of course, is not practical unless somewhat complicated apparatus is used. Speed control of all cars entering a given section can be effected by varying the frequency or voltage of current supplied to such a section, though necessity for that should be remote. Braking on approach to curves, crossovers, stations, etc., can be secured electrically by the use of similar frequency control or by reversed feeders together with change in grid design. Regenerative braking is very simply secured if there are stretches of sufficient downgrade.

FIG. 3. HEAD-END VIEW OF MAIL-CARRIER CAR IN SKELETON TUBE

The tendency toward reduced efficiency on account of slight irregularities in the track structure and a somewhat increased length of air gap between the primary and secondary sections over that secured in an ordinary motor may be largely compensated for by the elimination of rotating parts and gearing on the car. It is evident that there is a direct utilization of magnetic torque be-

tween the car and the track without resort to mechanical devices and their attendant friction.

The most apparent disadvantage which such a scheme as described would seem to show is that the cost of track equipment is somewhat greater than would be the case of equipping each car with a complete motor. The builders claim, however, that it is their experience that the

FIG. 4. A 1200-LB. ELECTRIC-CARRIER MAIL CAR

cost of thus equipping the track with the secondary element is not as heavy as might be expected, and this factor becomes of relatively small importance wherever such a carrier system is necessary, for then the space interval between cars is so small that the idle part of the track equipment is reduced to a minimum, and the investment charges are spread over a large tonnage.

A number of small-sized demonstration plants of short run have been built and recently the designers have completed the construction of about a half-mile of demonstration and experimental system in Paterson, N. J. Here are found four sharp curves and two 400-ft. tangents arranged with three sidings, one of which rises on a 20% grade and drops again to the level on the same grade. The curves here are of a minimum radius of 40 ft., the track being banked as in regular railway practice. The attraction between track and car motor elements helps to keep the car down on curves while the overhead rails assist. In daily service an outer-guide rail might be needed on sharp curves at full speed.

The Paterson plant has equipment designed particularly to meet the needs of city mail transfer and a loading and unloading station has been built with two of the sidings passing through it. This building also serves as a laboratory for the study of the system, there being many things about such a new system that have required original data for proper design.

At first the track was equipped with fixed motor members underneath and above the cars. But it has been found that the overhead secondary element was not required even for the 20% grade. This elimination of the upper section also simplifies the design, leaves the top unincumbered and reduces the cost. The type of car used at this plant is shown in Figs. 3, 4 and 5. They have a 300-lb. load capacity (the maximum mail load here is fixed by displacement rather than weight), and are designed to maintain practically the same speed loaded and empty (since windage is found to be the principal resistance) so that the cars will closely maintain their spacing in the tubes without attention. In Fig. 5, the sides and top of the car have been removed to show the large proportion of space available for burden and the freedom of the interior from all obstructions. A trailer of equal weight has been regularly used with these cars without appreciably lowering the speed.

The car has been loaded with 1000 lb. of sand without changing operation, overheating the motor or reducing speed from normal (30 mi. per hr.). Considering the car weight this was about a 27% overload on the motor.

Three conductors are needed for the three-phase current supplied. As shown in Fig. 3, there are two insulated overhead rails with contact wheels on trolley frames to lead the current to the motor primary circuit. The track is used for the third (return) conductor.

Collision between two moving cars in the same section of the track is little to be feared, for very small increase in slip between the speed of the shifting magnetic poles and the speed of the car produces a large torque increase. Should one car be stalled, due to derailment or other

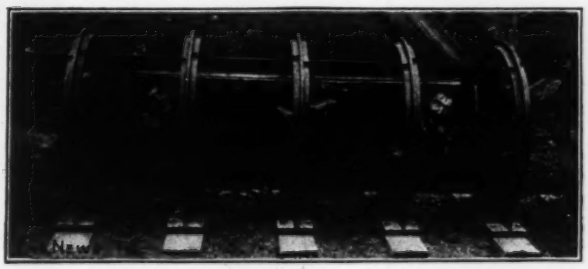


FIG. 5. MAIL CAR WITH SIDES AND TOP REMOVED

accident of like nature, then danger of successive piling up of cars back of it could be made very small. With the stoppage of the first car there would be a rush of current in the feeders of the conductor rails for that section, which would necessarily open the circuit breakers or other protective devices and completely cut off the supply of power from that section, stopping all cars therein. Naturally, during the development work for the 36-in. line described, a few such accidents as derailments have occurred. At these times only a few of the track supports have been damaged and the repairs to the track motor element (which was crumpled) and to the car have not been difficult.

Signal indications of the positions of cars along the route are given by windings in the motor track element. Voltage is induced in them by the passage of the car and may be led to train-annunciator circuits, etc. Each car could, if necessary, be made to operate the switches for its own sidings or turnouts by proper location of contact devices or trips; the aproach section of a branch could similarly be made dead while the switch was occupied. The Paterson yard is being so equipped.

Tests are being made to derive such data as may be necessary in the design of commercial installations but none of this is yet available.

This system has been developed by the Electric Carrier Co., 220 Broadway, New York City. Most of the design of the present equipment has been made by C. B. and J. F. McLeer, of the McLeer Electric Co., Brooklyn, N. Y., with Geo. T. Hanchett and E. W. Van C. Lucas, of New York City, as consulting engineers.

(To be concluded by a description of the direct-current system and demonstration plant of the American Pneumatic Service Co., Boston, Mass.)

A Builders' License Law for the City of Boston, Mass.

An ordinance providing for the licensing of all builders in the City of Boston is about to be put into operation. The law provides that no one shall have charge of any building operation without first procuring a license from a duly commissioned Board of Examiners. It further specifies that the different types of building operations shall be divided into classes to be decided upon by the Board of Examiners, which shall pass upon the qualifications of applicants and certify them to the building department. A fee of $2 is charged for the license, which is held by the builder until revoked for cause. Special provision is made in the law for an investigation of builders who presumably have failed in their duties, and a penalty is provided for violation of the ordinance. The ordinance reads as follows:

ORDINANCE FOR THE CONTROL OF BUILDING OPERATIONS, BOSTON, MASS.

1. All persons who shall hereafter take personal charge or control of the work of construction, alteration, removal or tearing down of buildings or structures in the City of Boston shall be qualified by education, training, or experience for the performance of that duty in a manner which shall preserve public safety and conform to the laws, ordinances, rules and regulations relating to the construction, alteration, removal or tearing down of buildings or structures in the City of Boston.

2. The qualifications of such persons shall be determined by a Board of Examiners as hereinafter provided; and no permit for the doing of work described in section one of this ordinance shall be issued by the building commissioner unless the application for a permit therefor contains the name, address and signature of a person who is duly licensed, as hereinafter provided, to take personal charge or control of such work; provided, however, that a permit may be granted if no person licensed as aforesaid has been named in the application therefor whenever the work in question is of minor importance, and, in the opinion of the building commissioner, stated in writing with his reasons therefor upon the application for such permit, the work is of such simple character that its execution will not endanger the safety of the public, or of any person engaged thereon.

3. There shall be in the building department a board to be called the Board of Examiners. Said board shall consist of three members to be appointed by the mayor. Each member shall receive $10 for every day or part thereof of actual service but not more than $1000 in any year. The first appointments, shall be for one-, two- and three-year terms respectively, and succeeding appointments shall be for terms of three years.

4. The board shall, as soon as practicable after the appointments of the members have become operative, meet and organize by the selection of a chairman and a secretary; and shall hold examinations, under reasonable rules and regulations adopted by it, of persons desiring to be registered as qualified to have charge or control of the construction, alteration, removal, or tearing down of buildings or structures. Due notice of examinations shall be posted in the offices of the building department and of the Board of Examiners and published in the "City Record."

The board shall establish various classes of persons to be registered, shall determine the qualifications required for each class, and after examination shall register in each class the persons found to possess the requisite qualifications therefor. The name and address of each person so found to be qualified, with the designation of the class in which he is registered, shall thereupon be certified by the board to the building commissioner who shall make a record of the same which shall be open to public inspection.

5. Any person who shall by affidavit, together with such other evidence as may be required by the board, show to the board that prior to the passage of this ordinance he has had charge or control of the construction, alteration, removal or tearing down of buildings or structures in the class in which he applies to be registered, and shall satisfy the board that he is qualified by education, training or experience to have charge or control of such work, may, without any other examination, be registered in said class and be certified to the building commissioner as a person qualified within such class.

6. The building commissioner, upon the payment of a fee of $2 shall issue a license to each person certified by the board, and such license shall not be transferred. The fees received by the board and by the building commissioner shall be paid over to the city collector at least once a week.

A person who has been duly licensed as aforesaid shall be entitled to have charge or control of any work described in section one of this ordinance, in the class in which he is registered, until his license is revoked or suspended by the building commissioner upon the order of the board. No license shall be revoked or suspended except upon proof of charges, filed with the board by the building commissioner or other person, specifying that the licensee has been careless or negligent in the performance of his duty in connection with work under his charge or control, or has caused or permitted a violation of the building laws in connection therewith, or that such laws have been violated in connection with such work when the licensee knew, or, in the exercise of due diligence, should have known, that such violation had occurred. Upon learning of such carelessness, or neglect of duty, or of such violation of law, the building commissioner shall file charges with the board and prosecute the same. Upon the filing of such charges by the building commissioner, or other person, the board shall give to the licensee notice of a hearing upon the charges which shall be held by the board not less than seven days after the date of said notice. The notice shall be by personal service or by registered mail and shall state the time and place of the hearing and contain a copy of the charges. At such hearing the licensee may be represented by counsel, and the building commissioner may be assisted by a representative of the law department of the city.

8. If, for any cause, a person licensed as herein provided, shall cease to have charge or control of any work described in section one of this ordinance before such work is finished, the work shall stop until another person duly licensed for the doing of such work has been placed in charge thereof.

9. Whenever the board shall determine that a sufficient number of persons has been licensed in the various classes, it shall post notice of such determination in the offices of the building department and of the board and publish the same in the "City Record." No person shall, by reason of anything contained in this ordinance, be denied a permit by the building commissioner or suffer any penalty until after the expiration of thirty days from the date of said publication in the "City Record."

10. Whoever violates any provision of this ordinance shall be punished by a fine of not more than fifty dollars for each offense.

The Board of Examiners has divided the classes of registration into:

Class A: charge or control of the construction or alteration of first-class buildings. ("First-class buildings" are all fireproof buildings, according to the best modern practice.)

Class B: charge or control of the construction or alteration of second-class buildings. ("Second-class buildings" are those whose external walls are fireproof.)

Class C: charge or control of third-class buildings. ("Third-class buildings" are frame buildings.)

Class D: charge or control of the moving or shoring of buildings or structures.

Class E: charge or control of the tearing down of buildings or structures.

When the ordinance was first passed there was considerable agitation against it among the master builders of the city, who seemed to be of the opinion that the master builder only should be licensed. After a hearing by the Board of Examiners, however, it was decided to grant a license according to the above noted classes to anyone who could show that he was qualified to take charge or control of building operations of the respective classes.

The Board of Examiners has been working on the law for some time, but it will not be put into effect for a few months. Before setting the precise date the board is endeavoring to get as many applications as possible. About 1500 applications for different type classes of li-

censes have been received; it is probable that a number of applicants will not receive a license, but as yet the exact number cannot be determined. So far, licenses B and C seem to predominate. License A is applied for mainly by superintendents and foremen of the large building companies, men who have charge of a varied assortment of work, and have applied generally for licenses in all five classes.

The Board of Examiners at present constituted comprise John T. Scully, chairman, a graduate of the Massachusetts Institute of Technology; secretary, Thos. K. Reynolds, a brick-layer by trade, and Wm. H. Besarick, an architect, of wide experience.

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The Clarification of Sewage in Slate Beds*

By Dr. Bach

Translated by Kenneth Allen† and Edward S. Allen‡

[Although the results of experiments on the use of slate beds at the sewage experiment station of the Bureau of Surveys of Philadelphia received favorable comment in a report published in 1911, the adoption of such beds in the United States up to the present time has been practically nil. The following translation of a paper by Dr. Bach, of Essen, Germany, comprises a lucid description of the construction and operation of slate beds with data concerning their efficiency, limitations and cost which will be valued by those who are interested in questions of sewage—or, more properly—sludge disposal.—Translators.]

The historical development of the technic of sewage treatment, which is yet young, began, as is well known, in England. There the introduction of the water-carriage system early called for the purification of sewage before its discharge into streams; and English engineers have worked continually and eagerly for the further perfection of purification processes.

A notable method of sewage treatment, which has recently been developed in England from small scale experiments which were bitterly criticized at first but which have now secured wide-spread recognition and adoption, is clarification by Dibdin Slate Beds.

The treatment of sewage in slate beds is, according to the inventor's opinion, the final stage in the development of the biological processes, in that it achieves an aërobic treatment of both sewage and sludge. The sludge consists of undissolved material with a certain amount of moisture in which colloidal matter may be, and generally is, contained; and above and separate from the sludge there remains the more or less clarified sewage. The latter contains, as originally, the matter in solution and also, since no clarification process is perfect, a residuum of undissolved and half-dissolved matter.

In this way the question of sewage treatment may be separated into two problems: viz., *the treatment of sludge* and the *subsequent treatment of the liquids.* Various methods of solving each of these problems are known, all of which have in common the need for their complete operation the activity of small organisms. These may be considered in two groups, the *aërobic* which require oxygen and the *anaërobic* which demand little or none. According as one or the other group predominates we may speak of the several kinds of treatment as aërobic or anaërobic.

There is at present no doubt that sprinkling filters present the best artificial biological treatment for clarified sewage. We leave out of comparison the *natural* purification processes known as land filtration and dilution in relatively large streams. The action of the sprinkling filter is entirely aërobic since the purification effected depends on the minute organisms which demand oxygen. Dibdin's efforts have been directed to providing an aërobic sludge treatment parallel to the aërobic treatment of sewage. The solution of this problem was decidedly more difficult than that of the aërobic treatment of clarified sewage since its physical condition renders an anaërobic treatment of the sludge more obvious and at first

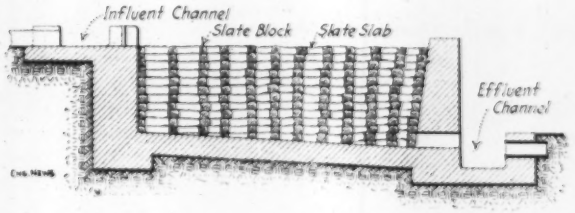

Fig. 1. Cross-Section of Dibdin Slate Bed for Sewage Treatment

easier than an aërobic one. This is because in settling tanks the sludge reaches an anaërobic space, whereas the liquids come in contact with the air, which is the [main] source of oxygen for the aërobic bacteria. It was a natural consequence of this situation that an aërobic treatment of the liquids was supplemented by an anaërobic treatment of the sludge. The latter has given entire satisfaction. For instance, it is well known that the anaërobic treatment of sludge in Emscher tanks furnishes an inoffensive, easily handled product, which always reduces to a material extent the difficulties involved in sludge disposal.

The problem of an aërobic treatment of sludge depends upon the practicability of bringing the entire mass uniformly in contact with the air. Dibdin succeeded herein by the happy thought of using slate, which occurs in large quantities and of excellent quality in England, to construct in ordinary settling tanks such an arrangement of slabs that the air could have free access to the whole tank. The cross-section of such a slate bed is shown in Fig. 1. On cubical blocks of slate, slate slabs are loosely laid, on this first course a second is placed, and so on to the upper edge of the tank. The bottom of the tank slopes slightly toward the outlet. When such a slate bed is filled with crude sewage, each compartment inclosed between two layers of slate acts, to a certain extent, as a separate settling basin, so that the entire tank is divided into small, flat sedimentation tanks. The function of the slate bed differs at first from that of an ordinary settling tank only in distributing the sludge in thin deposits on the many slabs instead of in one thick layer on the floor of the tank. The slate bed, filled with

*From "Technisches Gemeindeblatt," Mar. 5 and 20, 1913.

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sewage, is then left undisturbed for the separation of the sedimentable suspended matter, for a period equal to that required for the same purpose in a common settling tank—that is, about two hours. At the end of this time an outlet valve (Fig. 1) situated at the floor level in the wall at the effluent end is opened and the sewage flows off.

This effluent does not differ essentially at first from that of any other settling tank having the same period of retention. When the sewage has flowed off, the fresh sludge is left spread in a thin layer on the slabs.

During the ensuing period of aëration the valve remains open and a current of air passes through the entire bed, so that the whole mass of sludge, which covers the slabs in thin layers, is brought into contact with the oxygen of the air. After six hours of aëration the bed is filled with sewage and a new thin deposit of sludge is added to the aërated layer already there; this new deposit is in turn subjected to aëration after the sewage is drawn off. Under the influence of these periodic aërations the accumulated sludge deposits become a culture medium for aërobic organisms which transform it into a substance which Dibdin designates as "humus." It is noteworthy that in this sludge layer not only bacteria but higher organisms as well come to life in great numbers. These, favored by the oxygen available, feed on the organic matter in the sludge. A certain length of time is naturally required for the development of these organisms; i.e., the slate bed must "ripen." In the ripe bed this life is maintained by the regular accession of fresh nutriment and air, so that in a slate bed once matured the biological decomposition of freshly deposited sludge proceeds uniformly. The many worms burrowing through the sludge on the slabs and devouring or tearing apart the organic fecal matter give the sludge a porous character that further promotes the access of air. As for the volume of the sludge, that is notably diminished by the biological process; first, because on account of its altered physical character it parts with moisture, as in the case of decomposition in a digestion chamber; and second, because (again as in a digestion chamber) a part of the substance passes off as gas, namely, the carbonic acid given off by the higher sludge fauna. Nevertheless, the spaces between the slabs would be clogged up by sludge within a limited time and the capacity of the bed for sewage destroyed were it not for a third circumstance. As has already been said, the effluent from the early fillings of a slate bed is clarified to about the extent of that from an ordinary settling tank having the same period of retention. In this early part of the slate bed's operation the fresh sludge clings to the slate as a thin, sticky mass. But when the bed has ripened, i.e., after biological decomposition of the sludge has set in, a certain amount of the decomposed sludge or "humus" floats off with the effluent. This fact shows that the humus carried off nearly balances the sludge deposited, so that the capacity of the bed for sewage decreases at a very slow rate. It may be contended that as the effluent contains suspended matter which would have been held back by a settling tank the clarification is illusory. To this we may reply that the humus so discharged has quite a different character from the matter held in suspension by the inflowing sewage. Whereas the latter, because of the large amount of fine organic matter of low specific gravity, settles slowly and so produces a sludge containing a large proportion of water, the humus is largely mineralized, contains but little water, settles quickly and gives a porous deposit of small volume. Suitable humus traps of brief settling period and small dimensions are, therefore, sufficient to free the sewage completely from humus, much as if none were flushed out of the bed.

It appears that decomposition of the sludge proceeds in such a way that the greater part of the organic matter is used as nutriment for the living organisms, either becoming incorporated in them or else passing off to the air fully oxidized as carbonic acid. The product carried away by the effluent is that from which the living organisms have abstracted most of the organic matter. Naturally some of these organisms are carried out at the same time, and as they are composed of organic albuminous matter they would putrefy under anaërobic conditions. As a matter of fact, if humus is kept in a closed receptacle a strong odor of putrefaction is observed after a few days. If, on the contrary, humus is treated aërobically (e.g., on drained drying beds) the oxygen of the atmosphere produces, as soon as the organisms have died off, a sort of mouldering or weathering without putrefaction; the bodies of the numerous worms shrivel up, opening up the humus still more to the influence of the air, so that there remains at last an inoffensive, crumbly, porous product. Often large worms are found alive when a lump of humus at this stage is broken. The name "humus" given this material by Dibdin is justified by its marked similarity to garden soil which, when equally porous, contains worms and other living organisms. Dibdin proposes the name "living earth" for the sludge on the slate slabs, since that mass is permeated with both visible and microscopic life, worms, infusoria, nematoda and a great wealth of bacteria.

From its nature the dry humus is adapted for use as fertilizer, for making the soil light and porous and for filling in land. For these purposes it is very similar to the spadable sludge from Emscher tanks which, apart from the final drying, is obtained by the opposite anäerobic treatment.

From the foregoing exposition it is clear that we have in the slate bed a *method of sludge treatment* and that the clarification of the sewage does not differ essentially from that in simple, well-designed settling tanks with a similar period of sedimentation. It seems, indeed, that the living earth, during its contact of two hours with the sewage, imparts to the latter a certain biological action, but this action can be but of minor importance since the surface of contact is small as compared with the volume of sewage. That is, in the evolution of the slate bed from the contact bed the capacity for sewage was notably increased, while the contact surface of the bed for a given volume was notably diminished. There is no doubt that the inventor himself did not at first regard the slate bed primarily as a means for treating sludge. He considered the bed of slabs at first as an improvement on the coarse contact bed and considered slate as a suitable material for retaining the sludge; for there was no danger of clogging the bed, inasmuch as a stream of water could easily clean the plates of deposit, while in a contact bed the sludge remains in the interstices. With regard to the development of slate beds from contact beds I would refer to Schiele's description of the clarification plant at

Devizes.* Schiele examined this and other plants with slate beds in an earlier state of operation, and when I saw them in June, 1912, I received the impression that Dibdin and the superintendents of the plants have come to regard the contact action on the liquid merely as of secondary importance and to conceive of the slate bed as essentially a settling tank with provision for sludge treatment. Dibdin himself states definitely that he thinks a subsequent treatment of the effluent necessary.

If, then, we are to criticize this method we must compare the results of its sludge treatment with those of other treatments and leave the clarification of the sewage quite out of consideration. The capacity of a settling tank can be determined from an economic point of view only by consideration of the times of filling and emptying and the intervening periods.

To judge of the applicability of slate beds in any particular case this point of view must be kept in mind, remembering that this is a method of sludge treatment and not one of sewage purification.

Among the places where Dibdin slate beds are in operation are the following:

DEVIZES—Here is located the oldest plant equipped with this system. Until 1905 chemical precipitation was employed and the sludge was pressed, producing 700 long tons of cake annually. In that year, after extended experiments, the plant was remodeled after plans by Dibdin. At present it consists of six slate beds for the dry-weather flow, two more for storm water and eight contact beds for the subsequent treatment of the effluent from the six slate beds. The population served is 7000. The sewage is collected by the combined system and flows from three sewers into a small mixing chamber at the clarification plant. It contains a considerable proportion of trade waste, viz.: the effluent from two large breweries, eight slaughter houses, a large bacon factory, two large dairies and some small factories for food products. It is hence rich in putrefactive matter and is considered one of the most concentrated sewages in England. The daily flow is about 908 cu.m. (240,000 gal.), i.e., about 1301. (34.3 gal.) per capita. From the mixing chamber, which is small and retains no solid material, the dry-weather flow passes directly to the slate beds. At present the coarser solids are kept back by a wooden screen in the distributing channel, having 4½-cm. (1.8-in.) spaces. Each of the six slate beds measures 20.4x135 x1.2 m. (66.9x44.3x3.9 ft.) The bottom is flat and slopes 15 cm. (6 in.) down to the outlet. The filling of the bed takes 3½ hours, the period of contact is 2 hours and emptying takes 3½ hours, so that the cycle of operation comprises 9 hours. Such beds can therefore be filled and drained but once a day. At night, because of the small volume of sewage, the cycle takes much longer, the filling alone requiring 6 or 7 hours. The outlets of these 6 slate beds deliver to a channel which serves as a distributing conduit for the eight contact beds. The humus flushed out from the beds settles in this channel, and as soon as the contact beds are full this is taken to special drying beds underlaid by coke breeze. In plants of more recent construction small settling basins—humus traps—are provided in the distributing channels which, in turn, are furnished with gates opening to the drying beds. Fig. 2 gives an idea of this arrangement.

The effluent from the slate beds passes to the eight contact beds. Each of these is 20.4x13.5x1.2 m. (66.9x44.3x3.9 ft.) in size. The bottom 27 cm. (10.8 in.) are of material about 18 cm. (7 in.) diameter, and from this upward the material becomes gradually finer. The upper 24 cm. (9.6 in.) are of coke breeze and rest on a layer of slate slabs. The surface of the contact beds is raked off at rather long intervals. The times of filling, rest and emptying are the same as for the six slate beds. The effluent is frequently used to irrigate land of which 3.2 hectares (7.9 acres- are available. It finally flows to the small Poulshot Brook and thence to Kennet Avon Channel, a navigable canal.

The two storm-slate beds serve as an emergency clarification plant. These must be filled even before the dry-weather flow is diluted three times. Any excess above a six-fold dilution flows by an emergency outlet to the stream without other clarification than that furnished by a grit chamber. The basin which serves as a grit chamber was not built for the purpose, but was converted from the earlier plant to its present use. Dibdin is of the opinion that grit chambers are unnecessary for slate beds; and this seems probable, as grit is easily flushed out with the humus and passes to the drying beds. Each of the storm-water beds is 24x20.4x1.2 m. (78.7x 66.9x3.9 ft.) in size. The time of filling depends on the volume of storm water while the period of contact is decidedly shorter than in the other six beds. The effluent is not treated further, but flows directly to the stream. The humus is handled in the same manner as that from the dry-weather beds.

The superintendent of the clarification plant states that the beds have not been cleaned during their five years of operation although they are provided with connnections from the water mains for flushing the slabs; also that the capacity of the beds is automatically maintained by the removal of humus at every emptying. The costly nuisance formerly resulting from the use of chemical precipitation and sludge pressing has quite disappeared. In place of 700 tons of useless sludge cake there is now but a very small quantity of humus, which serves as an excellent fertilizer.

For my own part I must say that I was very favorably impressed by the character of the humus. Fresh deposits were almost odorless, being scarcely noticeable when I stood by fresh piles of it. It contained many worms. Old humus resembled garden earth or peat and was, as I have said, in many respects similar to the dry spadable sludge from Emscher tanks. Its value as a fertilizer appeared to me obvious, as I saw healthy vegetation on old heaps and vegetables of excellent appearance on land fertilized with it. There is apparently this difference between humus and Emscher sludge: that in the decomposed sludge there remain much fewer fibers and leaves of plants, whereas humus contains many well preserved leaves. Furthermore, humus contains many worms, dead and alive; these are lacking in the digested Emscher sludge although they usually make their appearance later in the dried heaps. In spite of the warm season I noticed but few flies on the humus dumps. The amount of fresh wet humus produced by the plant is 4 long tons a week, but this shrinks to about one ton by long drying; that is, there are annually 50 to 60 long tons of dried humus instead of 700 long tons of sludge cake, as formerly.

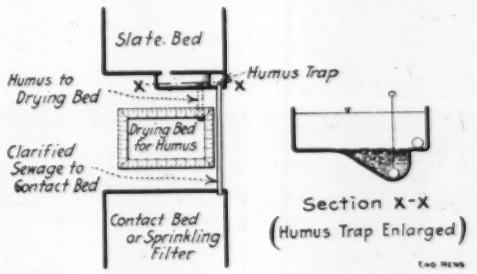

FIG. 2. TYPICAL ARRANGEMENT OF SLATE BED, HUMUS TRAP, DRYING BED FOR HUMUS AND CONTACT BED OR SPRINKLING FILTER

DATA PERTAINING TO THE DEVIZES PLANT

	Per capita
Daily volume of sewage	130 liters = 34.3 gal. or 4.55 cu.ft.
Volume of dry weather slate beds	269 liters = 9.42 cu.ft.
Volume of contact beds	331 liters = 11.59 cu.ft.
Volume of emergency slate beds	167 liters = 5.85 cu.ft.

The volume of these beds is not to be confounded with their capacity.

	Per capita
Total volume of slate beds	436 liters = 15.26 cu.ft.
Daily volume of moist humus	0.082 liters = 0.0029 cu.ft.
Daily volume of dry humus	0.02 to 0.025 liters = 0,007 to 0.0009 cu.ft.

For purposes of camparison it may be mentioned that in the oldest clarification plant of the Emschergennossenschaft at Recklinghausen the space for clarification and digestion together is but 31 l. (1.09 cu.ft.) per capita, the daily volume of sewage being 300 l. (80 gal. = 10.5 cu.ft.) per capita. The amount of wet digested sludge is, on the other hand, about 0.12 l. (0.42 cu.ft.) per day, an amount greater than that of humus at Devizes.*

*"Mitteilungen der Königl. und Prüfungsanstalt für Wasserversorgung und Abwasserbeseitigung," Vol. II, p. 181.

*The experimental slate bed at Philadelphia covered 0.0021 acre and was 5 ft. deep, i.e., its volume was about 450 cu.ft. The slate slabs were separated 3 in. apart by blocks of brick. With suspended solids in the sewage reaching as much as 660 p.p.m. the effluent contained but 31 p.p.m. The best results were obtained with two fillings per day. The capacity of the bed was nearly restored by flushing. The sludge as deposited amounted to 1.17 cu.yd. per million gallons of sewage and contained 54.4% moisture. In character it resembled a gritty mud, containing worms, but without odor. Of the dry residue less than 12% was volatile, 0.35% nitrogen and 0.55% fats.—Translators.

HIGH WYCOMBE is a country village with charming surroundings, a favorite place for the better class of London excursionists, so that the prevention of unpleasant odors is particularly important. The disposal of fresh sludge from the settling tanks connected with the contact beds was formerly a source of intolerable nuisance, and this led to the experimental conversion of a part of the tanks into slate beds. For several years of operation these two beds, constructed on the same lines as those at Devizes, have given such satisfaction that slate beds will soon be constructed in all the other settling tanks. I was able in this plant, also, to ascertain the excellent odorless quality of the humus and to note the marked contrast between it and the intolerably offensive sludge taken some time previously from the settling tanks. The volume of the two slate beds at High Wycombe is 114.4 cu.m. (4040 cu.ft.) After the beds had been matured the space available for sewage, after deducting the volume of the slabs and their deposits of humus, was reduced to 65.8 cu.m. (2419 cu.ft.), 57.5% of the volume of the tanks. The amount of humus carried off was also measured. In six months the beds handled 40,300 cu.m. (10,646,000 gal.) of sewage, and the amount of dried humus was 7.5 cu.m. (265 cu.ft.), about $^{18}/_{10000}$.

HAYLESBURY COLLEGE, HERTFORD—There is a slate bed installed for treating the sewage of Haylesbury College, an institution with about 650 pupils. The flow of sewage at the hours of bathing is 18 to 20 cu.m. (4750 to 5280 gal.) per hour and the rest of the day from 4 to 8 cu.m. (1055 to 2110 gal.) per hour. The sewage flows from the sewer to a measuring chamber having an effluent river from which it passes either to the slate beds or onto the land. The latter is customary with the dilute bath water, the former with the more concentrated sewage. There are four slate beds having a total volume of 64.5 cu.m. (2277 cu.ft.) The slabs of slate occupy 14% of this, leaving 56 cu.m. (1977 cu.ft.) for sewage. The beds are filled twice a day. They were set in operation in July, 1908. In July, 1909, the effective capacity of the beds was 49.4 cu.m. (1744 cu.ft.) and in 1911 it was 32.2 cu.m. (1525 cu.ft.). That is, in the first year and a half the capacity for sewage was decreased by about 23%, but since then it has remained practically constant. About 67% of the total volume of the tanks has remained available for sewage since the beds were matured. The effluent flows into a small settling basin for the separation of the humus, which is removed two or three times a week. The daily amount of moist humus is about 0.15 cu.m. (5.3 cu.ft.), i.e., about 0.23 l. (0.06 gal.) per capita. Air drying reduces this to 0.025 cu.m. (0.88 cu.ft.) or 0.04 l. (0.01 gal.) per capita. The effluent is further treated in contact beds (of earthenware shards) 60 c.m. (2.0 ft.) deep and about 828 sq.m. (3.9 acres) in area; i.e., of about 828 cu.m. (29,230 cu.ft.) volume. The effluent from these beds is quite well purified, but is again applied to land before discharge to Woolen Brook, a tributary of the river Lea. The weekly cost of operation of this plant, including the contact beds, is 27 M. ($6.45), i.e., M. (51.8c.) per capita per annum.

THE SURREY COUNTY ASYLUM has for some years had a similar plant, which has proved entirely satisfactory. The population served is from 800 to 900, of which 600 to 700 are patients. It is stated that, although it is near to other buildings there is no nuisance from the odors. The annual amount of dry humus is about 4.5 cu.m. (159 cu.ft.) = 5.3 l. (0.186 cu.ft.) per capita = 0.015 l. (0.0005 cu.ft.) per capita per day.

The principal remaining slate-bed installations in the United Kingdom are in the following places:

Aldershot, Military Camp	(Very concentrated sewage)
Curagh, Ireland Military Camp	(Very concentrated sewage).
Trowbridge	(Largely trade waste.) (Dyes, wool fibre.)
East Dereham	(About 33% from malt house).
Blaenau Festiriog	(Ordinary domestic sewage).
Machynleth	(Ordinary domestic sewage).
Sawbridgeworth	(Ordinary domestic sewage).
Uckfield	(Ordinary domestic sewage).
Halstead	(Concentrated and with tannery waste)
Thurascoe	(Contains coal slack and miners' bath water).
Ash	(Brewery waste).
Dundee, Sidlaw Sanitarium	(Much laundry water).
Surrey, Byfleet Cripples House, Gloucester, Oakhill	(Brewery waste).

NAIHATI, near Calcutta. The sewage from the large works of the Gourepore Co., with its 6500 employees, is treated by a slate bed. In all there is a flow of about 30 l. (8 gal.) per capita. The effluent from the secondary treatment is then disinfected with chloride of lime.

There are projected or under construction similar plants for:

The military branches at Northon (concentrated domestic).
The trade school at Feltham.
The insane asylum at Rampton.

Faversham, Harpenden, Newcastle-under-Lyme, Blean, Crediton, Exminster, Para (Brazil), and others in Russia and France.

In all these plants the effluent is to receive further biological treatment by contact beds or sprinkling filters and in many cases will be used for land irrigation. In many instances the storm flow as well receives a secondary biological treatment. The reports of the managers of the clarification plants are all favorable and many are enthusiastic. The good quality and small amount of the humus is always mentioned and it is everywhere remarked that after the beds are once ripened, the capacity decreases very slowly and can be brought back to its original figure by flushing the humus off the slabs with a stream of water.

As to the introduction of method of treatment outside of England, the cost of obtaining slate is of greatest importance. There the cost is very small—about 20M ($4.80) per ton. Transportation adds materially to the cost. The cost of laying the slabs in place can be made very small as the loose method of construction is very simple. The cost of land is an important item because the beds are constructed as horizontal basins and hence cover much more area than tanks of other deep structures, and also because only 60 or 65% of the space is available for sewage after the bed is matured and therefore the plant must be correspondingly larger than with simple tanks. Therefore, it seems to me that slate beds in Germany are not adapted to large cities, but rather for smaller communities where land is cheap and for isolated institutions, such as sanatoria, hospitals, military posts, etc. I wish again to emphasize the fact that, while the treatment separates and decomposes the sludge, forming from it an inoffensive product, the effluent requires no less purification than that of any other mechanical process.

The Silting of Harbors and the effect of piers and jetties upon the movements of sand along the shore line were discussed in a paper by Ernest R. Matthews at the recent meeting of the British Association for the Advancement of Science. The author pointed out that any seaward projection on a coast has the effect of arresting or checking the travel of the sand, whether the projection is a groin extending to low-water line, a breakwater, a harbor pier or arm of 1000 ft. in length, or a natural promontory extending some miles from the coast line.

In the case of harbor arms extending at right angles to the coast, this obstruction (especially on a sandy shore) impounds the traveling material on one side and often causes serious erosion on the other side. The sea-front at Yarmouth (England) has extended seaward during the past half-century an average of 300 ft., due almost entirely to the construction of the harbor.

At Madras (India) 650,000,000 cu.ft. of sand have accreted on the south side of the harbor within a distance of three miles of the harbor, and 450,000,000 cu.ft. of land has been eroded on the north side within a similar distance. The Madras authorities are now contemplating an extension of the harbor seaward at an estimated cost of about $15,000,000 in order to reduce the extent of the silting of the harbor.

The only method of escaping from the impounded material seems to have been to periodically extend the arm of the harbor further seaward, as proposed for Madras. This means a tremendous cost, and the results are often not satisfactory, for as the pier is advanced the shore also advances. It has been suggested that openings should be left through the shore ends of the harbor arms, for the sand to pass through. This is not practicable, for immediately the traveling material passes through the opening the wave behind it does not possess sufficient force to move the material through, especially where the width of the harbor is considerable.

Mr. Matthews suggested that instead of the piers running approximately at right angles to the coast, the pier on the side facing the direction of the traveling material should project at an angle of 45°. The additional area thereby inclosed by the piers could be utilized, among other purposes, for that of wharfage. The traveling material would then pass around the harbor projection, and would supply the coast on the lee side of the harbor with a natural protection of sand.

Reinforced-Concrete Boat Ways, Rockhaven Harbor, N. D.

By S. R. Morrow*

In the construction of the boat ways for government vessels at Rockhaven Harbor, N. D., the U. S. Engineer office, of Kansas City, Mo., has departed from the old practice of building such structures entirely of wood. Rockhaven Harbor is located on the west bank of the Missouri River about four miles above Mandan, N. D., and is the site of the repair plant for the fleet of government vessels used in the control of the river. The new ways there, shown in the view in Fig. 1, are of reinforced concrete with a timber "butter board" on top for the sliding plane.

There are ten ways, each 270 ft. long, the lower 130 ft. being on a 1 to 7½ slope and the upper 140 ft. level. They are spaced 14 ft. c. to c. and are supported on concrete columns 10 ft. c. to c. The largest vessel for which

Fig. 1. Reinforced-Concrete Boat Ways for Missouri River Fleet of U. S. Engineer Corps

they were designed is the snagboat "Mandan," a steel-hulled boat 155 ft. long and 24-ft. beam. Fig. 2 shows a detail of the construction.

The columns, with the exception of those at ends and top of slope, are 12 in. square and are placed to an average depth of 6 ft. in the ground. Where a good foundation was not struck at this depth an 8-in. post-hole auger was used in boring a hole to solid foundation. These holes were filled with concrete and were assumed to act as piling. With the exception of a few of the columns at the foot of the slope a good foundation of blue shale was generally struck at a depth of 6 ft. The columns were flared at bottom to 20 in. square, thereby increasing the bearing surface. As the earth had no tendency to cave, no forming was used underground excepting with the columns at waters edge, which were 4 ft. square and were built in the edge of a sand bar.

Each column was reinforced with four ⅝-in. square twisted bars which were bent over and projected 2 ft. 2 in. into the beams. The aggregate used in concrete was a native gravel which contained sufficient sand and some dirt. On account of this dirt a rich concrete was used, the mixture being 1:4. The water for concrete was pumped directly from the river to barrels at mixing platform by means of small plunger pump and hoist boiler. All concrete was mixed by hand and distributed in barrows.

The beams or ways proper, which are 12x14 in., were started after all columns were completed. The forms for these were made in two sides and bottom. One set

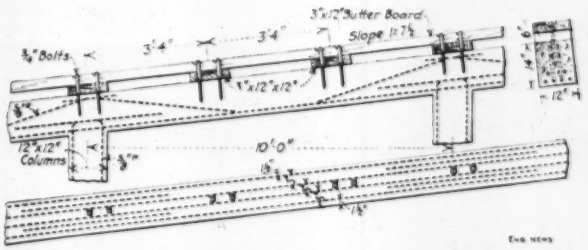

Fig. 2. Details of Beam and Column of Rockhaven, N. D., Boat Ways

of sides and two sets of bottoms were made for complete way, 270 ft. The bottoms were supported by clamps on the columns. The sides were also supported by these clamps. Hinged clamps were placed around the whole form, thus transferring part of the load from bottom to sides. The beams were allowed to set 24 hr., with side forms in place and from 48 to 96 hr., with bottom forms in place. It took approximately 11 hr. to concrete one beam 270 ft. long.

The beams were reinforced with two bent-up rods and two straight rods 2-in. from bottom. All rods were ⅝-in. square twisted steel. At first no provision was made for temperature stresses but a temperature crack appeared at top of slope in first beam placed. This was partially overcome in succeeding beams by placing extra reinforcement in tops of beams.

The "butter boards" are 3x12-in.x20-ft. fir sticks supported by 3x12x12-in. fir blocks, spaced 3 ft. 4 in. c. to c. Both blocks and "butter boards" are anchored to the concrete by means of ¾x12-in. machine bolts imbedded 7 in. in the concrete.

Work on the ways was begun in October, 1912, but the weather became so cold that only 145 of the columns were gotten in place when work was suspended. Work was resumed June 27, 1913, and the remaining 145 columns with all beams were completed Aug. 12, 1913. Major Herbert Deakyne, Corps of Engineers, U. S. A., is the district officer for the Missouri River and tributaries. Fred W. Honens, Assistant Engineer, is in general charge of the work on the upper Missouri River, and the writer was in local charge of the construction of the ways.

*U. S. Junior Engineer, Mandan, N. D.

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Coöperative Insurance for employees has been arranged by the Fourth Avenue Ry., of New York City, with the Travelers Insurance Co., of Hartford, Conn. These proposed policies are issued in lieu of a death benefit of $250 under the mutual benefit association affiliated with the company. For members of the association the average annual cost is to be about $11, but this rises to $12 for employees not members. The association will pay $4 of each member's premium and the remainder will be paid through the company, being deducted in weekly installments from wages. The payment of 75c. per year additional secures accident benefits varying from $250 for loss of thumb and index finger to $1000 for the loss of both hands or feet, etc. Anyone leaving the employ of the company may continue the insurance on paying the published rate for his age; the additional accident benefit may be secured after leaving the company's employ for an annual fee of $1.25.

The Carondelet Park Bridge, St. Louis, Mo.

By Charles W. Martin*

Grand Avenue, a link in the chain of boulevards connecting the various parks in the city of St. Louis, has recently been widened and improved from Meramec St. south to an intersection with Kansas St., which street forms the northern boundary of Carondelet Park. There a grade entrance into the park was precluded by the tracks of the Missouri Pacific Ry., which run diagonally across the park and cross Kansas St. just west of the Grand Ave. intersection, so that the construction of the following described bridge was necessitated.

Selection of type of structure—the arch—was influenced by neighboring topography. Its architectural treatment is intended to cause the structure to present a monumental appearance and somewhat beautify the park. The southwesterly alignment adopted for the park entrance driveway crosses the railroad tracks at an angle slightly oblique and affords easy transition from Grand Ave., north, and Kansas St. east. To the west, however, Kansas St. remains closed.

This bridge is of interest primarily on account of the boldness of its design. This characterization of the structure is used advisedly. The principal elements of the structure consist of a flat circular arch supported by cellular abutments with spread footings; approach retaining walls; railings; monumental pylons, cornices and railings embellishing the structure—all of reinforced concrete. The park entrance driveway is, in general, of 40-ft. width with 10-ft. sidewalk spaces on either side, making the deck width over the arch 60 ft.

Arch Span—The arch span (Figs. 2-3) is 95 ft., its rise above spring lines 7 ft. 6 in.—a ratio of rise to span little greater than one-thirteenth—and its general elevation such that a clearance of 18 ft. over the tracks of the Missouri Pacific Ry. is provided. The intrados and extrados radii are 154 and 179 ft., respectively, while the thickness of concrete is 18 in. at the crown and 30 in.

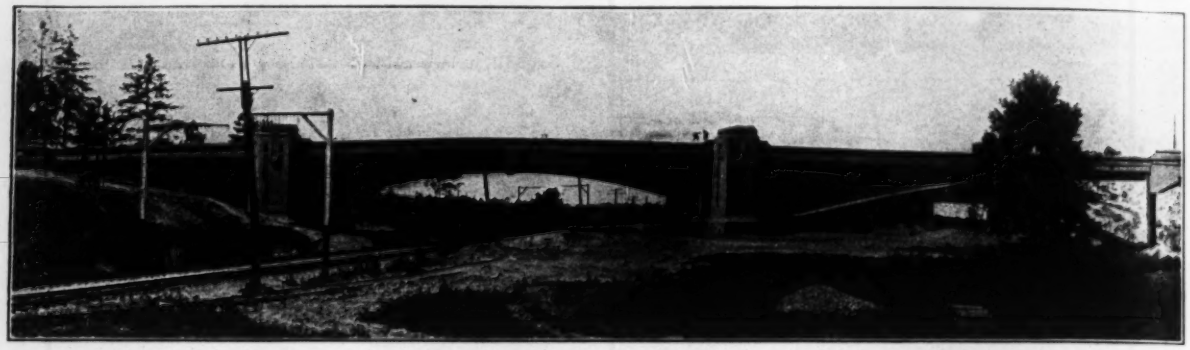

Fig. 1. View of Carondelet Bridge, St. Louis, Mo.

(Note that abutment on right has not been filled; eventually full line will reach the curved arching up from the abutment pier to the right.)

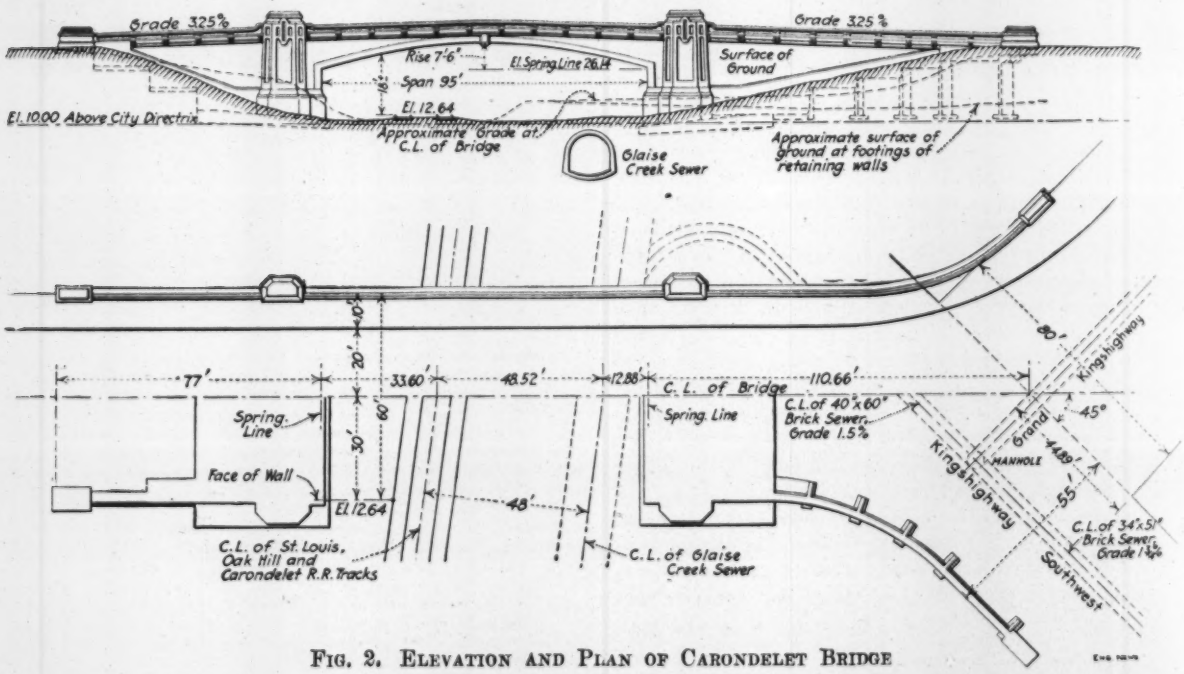

Fig. 2. Elevation and Plan of Carondelet Bridge

*Street Department, City of St. Louis, 6173 Berlin Ave., St. Louis, Mo.

at the spring lines. The longitudinal reinforcement of the arch consists of a system of 1-in. round bars in each face spaced, in general, at 4-in. centers, transversely. In the region of the crown and spring lines this arrangement is augmeted, in each face, by an additional system duplicate as to size and spacing with 2½ in. greater embedment while in the region of the quarter points of the arch the arrangement is reduced to 8-in. centers. Expressed as a relation to the sectional area of concrete the steel ratios for the longitudinal reinforcement are 0.043 at the crown, 0.008 at the quarter points and 0.026 at the spring line. The longitudinal reinforcement at the spring line extends back 6 ft. into the abutment skewbacks. The arch barrel is further reinforced with 1-in. round bars placed transversely in each face at 5 to 6-ft. centers and with a system of ¼-in. rectangular-shaped shear stirrups which tie in the longitudinal reinforcing at spaces varying from 6- to 12-in. centers.

FIG. 4. VIEW OF TOP OF ABUTMENT PIER

ABUTMENTS—Each abutment (Figs. 3-5) consists essentially of a face wall and a series of seven ribs supported by a spread foundation. The foundation slabs are each 75 ft. long, and 41 and 45 ft. in width for the southwest and northeast abutments respectively. They are at an average depth of 5 ft. below the track grade or 18 ft. below the spring-line elevation. In each the thickness of concrete varies from 2 ft. 3 in. at the abutment face to 3 ft. 6 in. at the back and their reinforcement consists of a two-way system of 1-in. and 1⅛-in. bars spaced from 15- to 18-in. centers in both the top and bottom planes.

The ribs are the cardinal agency for the conveyance of the arch ring forces to the footings. They are, say an average, 30 in. thick, spaced 9 ft. 6 in. centers and stretch from the abutment face wall back across the

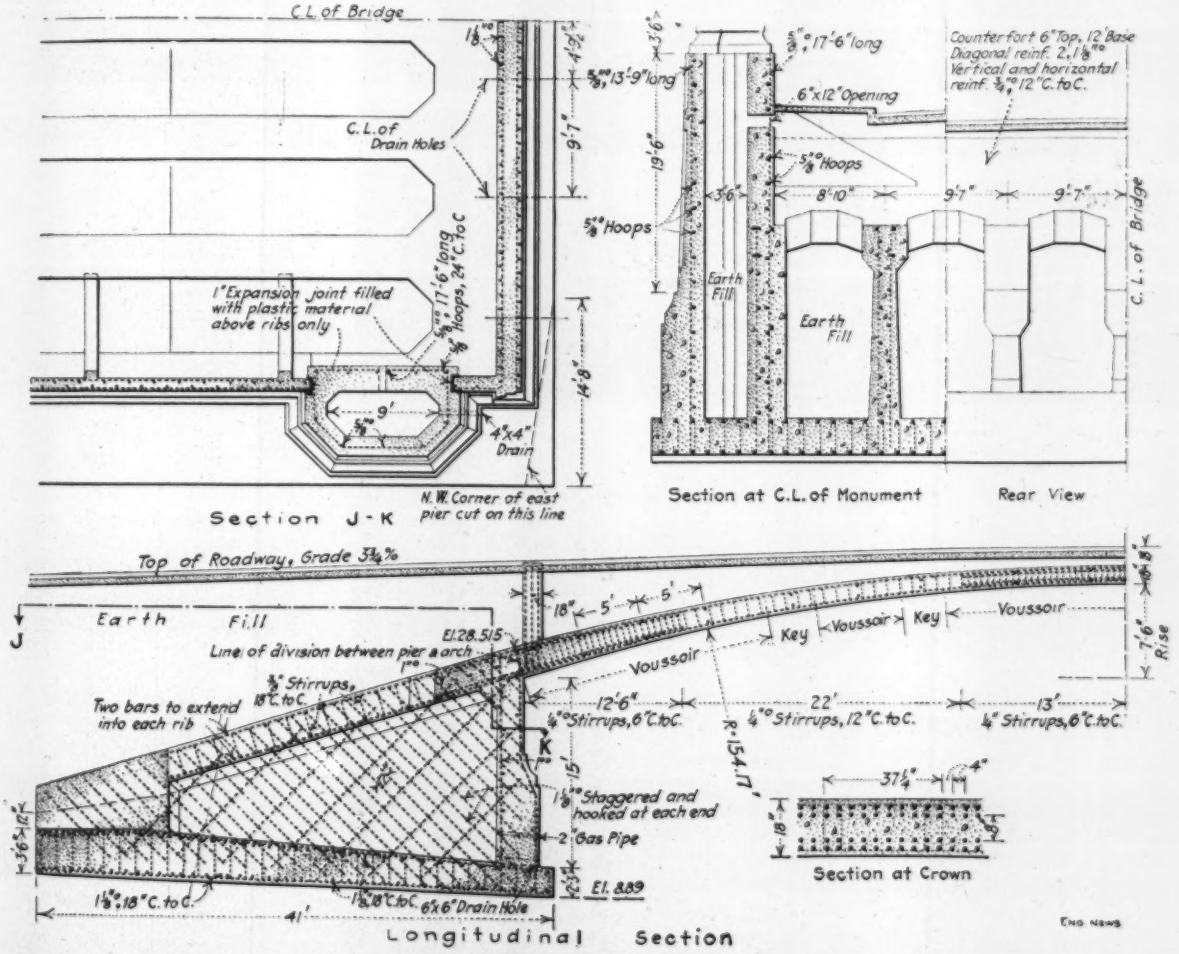

FIG. 3. DETAIL OF ARCH RING AND ABUTMENT PIER

foundation slab on a slope tangential to the arch extrados. Their principal reinforcement consists of a system of 1⅛-in. bars at 12-in. centers extending obliquely from the foundation slab and the face wall. The skewbacks cap and project back from the facewalls and flange the ribs. The vertical reinforcement of the facewall of each abutment reaches up into the skewback and engages the bars of the arch reinforcement as does also an auxiliary system of 1⅛-in. short diagonal bars.

Approach Walls—The approach retaining walls are of two types. Those of the southwest approach are of common counterforted variety and are not of especial interest. The walls for the southeast approach, however, are of unusual design. Here (Fig. 5) proper driveway transition into Grand Ave. and Kansas St. necessitated curved walls. The ground elevation was such as to require a 20-ft. embankment for the driveway and, for proper landscape effect, considerable general fill over

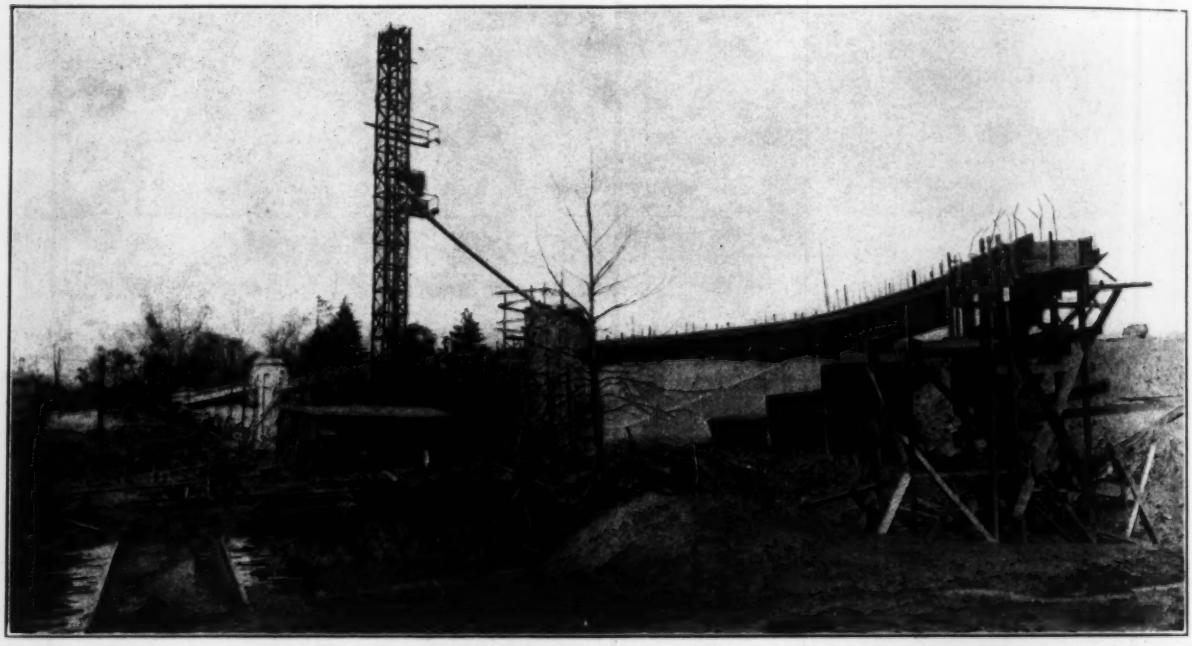

Fig. 5. View of the Curved Abutment and Southeast Approach during Construction

neighboring grounds. The type of wall adopted consists essentially of a series of stilts (Fig. 6) supporting a curved slab which reaches vertically from the grade of the proposed side fill to that of the bridge driveway. Throughout, the approach and spandrel walls are coped with overhanging cornices and paneled hand-railings which, with the end posts and the monumental pylons flanking the arch, add to the structure a certain gracefulness of line.

Design Methods—The arch was designed by "The Ellipse of Elasticity" method.* In addition to the dead weight of arch with spandrel filling and pavements, a nominal park driveway and sidewalk live loading was considered. These loads, together with the distortions resulting from changes of temperature of 30° F., either way, in the concrete develop figured critical maximum stresses of 750 lb. compression per sq.in. in concrete and 11,000 lb. tension per sq. in. in the steel. These figured maximums obtain at the spring line intrados and extrados respectively when the temperature in the concrete falls 30° F. from that at the keying. The figured horizontal thrusts, per lineal foot width of arch amount to +76,000 lb. for the static loadings and ±12,000 lb. for the nominal ±30° F. temperature change. Under static loads the figured unit bearing pressures upon the soil under the front and back of the foundation slabs are 1000 and 4800 lb. per sq.ft., an average for the whole foundation slab of 2900 lb.

Preliminary to the construction a soil bearing power test of 12 days duration was made in the southwest abutment footing trench. A bearing block of 4 sq.ft. area was loaded with 22,400 lb. of earth. The initial settlement was 0.050 ft. and at the end of 24 hours, 0.078 ft., while in the next 11 days a further settlement of only 0.003 ft. was noted. This loading was equivalent to 5600 lb. per sq.ft. and the settlements recorded indicated that some settlement was to be expected under the figured 2900 lb. average foundation loading. In order to somewhat improve the soil conditions by providing means for subdrainage—the soil being quite wet—the abutment trenches were excavated somewhat below the plan depth and layers of rock rammed in and lines of 12-in. drain pipe placed adjacent and below the front face of the foundation trench. These pipes were backfilled with loose rock and discharged into the "Glaise Creek Sewer"—a 12-ft. reinforced-concrete sewer which parallels the Missouri Pacific Ry. tracks and passes under the arch span. Previous to the construction of the arch such embankment as was possible without interfering with other parts, was filled in over the abutments so as to mitigate the effects of settlement.

Construction

All material for the structure was delivered to the site in cars and stored in bins and sheds paralleling a tem-

*See "Journal" of the Western Society of Engineers, May, 1913; a paper by A. C. Janni, the designer of the Carondelet Park Bridge.

porary four-car capacity switch. The concreting equipment consists of a ½-cu.yd. capacity mixer served by barrows from the storage bins; a 90-ft. tower with hoist and a system of suspended steel chutes which, by gravity, conveyed the concrete to the trenches and forms. The capacity of the plant was limited; primarily on account of the inadequacy of the hoisting power, to about 12 cu. yd. per hour and considerable "overtime" resulted in the construction of the larger sections of work.

The construction features of the arch, only, are noteworthy. Here the falsework consisted, in general, of transverse lines of mud-sills and posts on which longitudinal stringers were supported by "scabs." These stringers supported transverse joists carrying the arch form sheathing which was laid longitudinally. The lateral stability provided by this sheathing, the flatness of

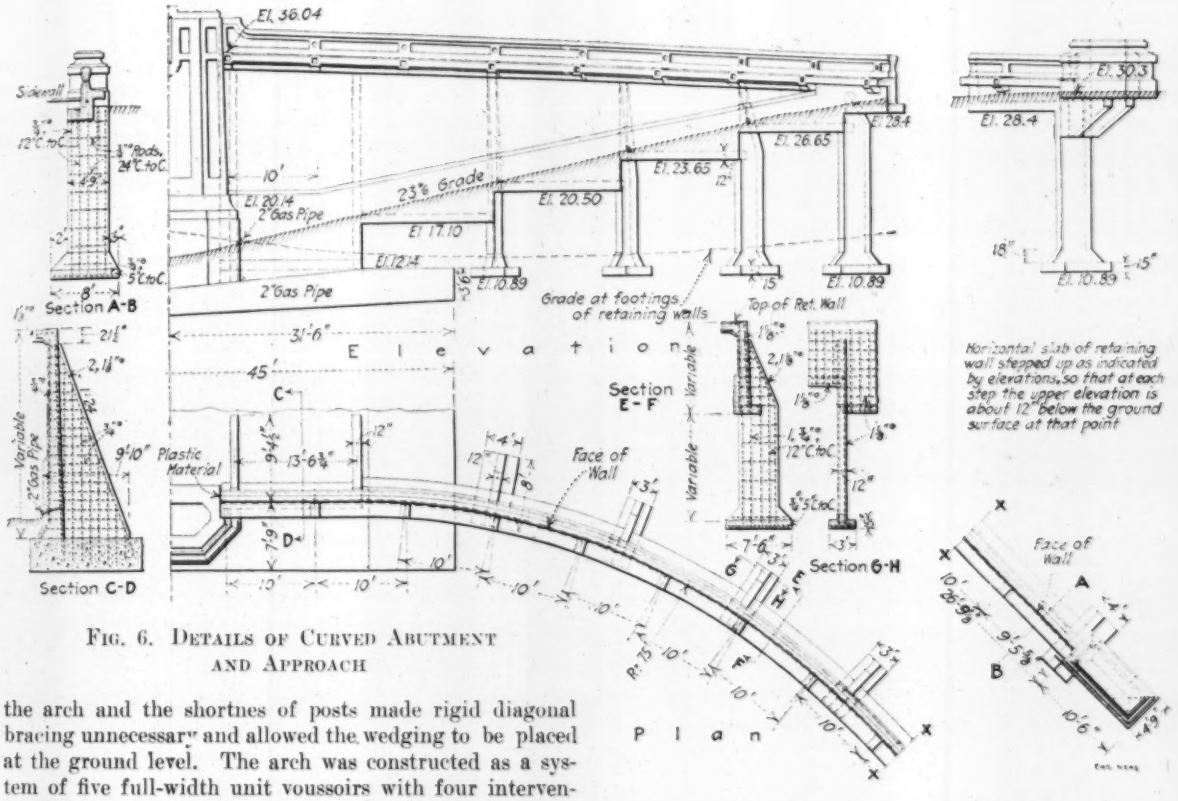

FIG. 6. DETAILS OF CURVED ABUTMENT AND APPROACH

the arch and the shortnes of posts made rigid diagonal bracing unnecessary and allowed the wedging to be placed at the ground level. The arch was constructed as a system of five full-width unit voussoirs with four intervening keys in which all lap splices of the arch reinforcement were made. The adoption of this method of construction contemplated the partial elimination of initial stresses by allowing the voussoirs to obtain initial shrinkage before concreting the keys. For each one-half of the arch the keys are situated just on either side of the quarter point—positions in which under the hypothesis of loading and temperature distortion assumed, overall compressive stresses prevail.

At the time of keying in the arch the average age of the voussoir concrete was ten days and the average atmospheric temperature 57° F. The falsework was maintained in place 30 days thereafter and its removal occasioned an initial deflection in the arch of ¼ in. at the crown point.

The concrete was of three classes—the mixture, maximum size of coarse aggregate and the employment of each being as follows:

Class	Mixture	Coarse aggregate	Employment
A	1:3:6	2½ in.	Footings
C	1:2:4	¾	Arch barrel
B	1:2½:5	1½	All other

For each the coarse aggregate—gravel—was graded down to ⅛ in. size and tests indicated voidages ranging from 40 to 43%. Round bars were used throughout and for the principal elements of the structure they were deformed and of medium steel.

The major portion of the concrete work was constructed during the past winter, which was probably a little more severe than the general run of winters in this climate. Considerable concrete was successfully placed in freezing weather. Then the aggregate was heated sufficiently to expell the frost; the amount of water used in the mixture somewhat reduced and the concrete protected with canvas and salamanders. The use of calcium chloride was allowed under the specifications but its retardation of the "set" was found undesirable and it was not generally used.

The finished concrete presents a smooth and fairly uniform colored appearance. The method of finishing consisted in removing form marks with chisels; rubbing the surface with carborundum and emery; applying a thin "cement-and-sand" wash with brushes and then directly rubbing it down again with the abrasives. The initial results of this method of finish are satisfactory. Its resistance to the elements is, however, questionable.

The quantities and unit prices bid by the contractor are as follows:

Item	Quantity	Unit price
Excavation	67,800 cu.ft.	$0.025
Concrete, Class "A"	21,800 cu.ft.	0.185
Concrete, Class "B"	39,450 cu.ft.	0.235
Concrete, Class "C"	10,850 cu.ft.	0.355
Reinforcement	377,600 lb.	0.0225

This makes the cost of the structure, complete save for earth embankments, spandrel filling and surface pavements, approximately $27,500.

The earth embankments are being made by convict labor with material obtained from landscape grading in the park in the vicinity of the bridge. The spandrel filling over the arch is to be made with cinders. Wood block pavement with concrete base, granite curbing and cement walks with granilithic finish are to be used for the surface improvements.

TEMPERATURE MEASUREMENTS—As before mentioned the design of this bridge assumed for the calculation of critical unit stresses, a change of 30° F. either way, in the mean arch ring concrete from the temperature at which it was keyed in. Some such assumption must be made. In order to furnish data on this point for use in future designs a system of bulbs which, with an indicator, electrically gage the concrete temperatures have been embedded in the arch at the crown, quarter and spring points. These temperatures as well as the rise and fall of the arch are observed at intervals and interesting data is expected from them and their relation to atmospheric temperature variations.

PERSONNEL

This work is under the direction of the Bridge Division of the Street Department of the city. C. M. Talbert is Street Commissioner and L. R. Bowen is Bridge Engineer. John V. Boland Const. Co. was the contractor. The structure was designed by A. C. Janni and the architectural treatment planned by O. E. Kessler, consulting landscape architect for the city. A. C. Janni, Winters Haydock and the writer were at various times in charge, in the field, for the city.

Panama Water-Supply and Purification System

BY ARTHUR T. NABSTEDT*

SYNOPSIS—The peculiar water-supply problems of the Canal Zone are reviewed and some contrasts with northern water-supply conditions are drawn. The necessity for large storage capacity, notwithstanding the heavy rainfall, and the effect of tropical conditions on quality, are shown. Finally, the evolution of purification works is described. Pre-coagulation, aëration, sedimentation and mechanical filtration are employed.

The most important problem which confronts the sanitary engineer of any construction camp, is that of procuring a good water-supply. By doing this he not only adds greatly to the comfort of the laborer, but guards against such intestinal diseases as typhoid and dysentery, whose commonest carrier is water, and whose power to propagate epidemics makes them the greatest enemies to the health and efficiency of labor.

That such a water-supply at Panama has been, not only the basis of a material reduction of typhoid and dysentery, but the solution of the yellow-fever question, is not generally appreciated. And it is scarcely with justice that the work along this important line of sanitary engineering has thus been neglected. The stegomyia is classed as a house mosquito, and its elimination depends upon the destruction of such breeding places as the rain-barrel and water-containing bottles, which generally ornament the immediate vicinity of the native habitation. Long periods of drought, however, made the rain-barrel as essential to the existence of the native, as was its removal essential to the sanitation of the canal. And it was plainly the duty of the American engineer to replace those necessary breeding-places by a chain of reservoirs, sufficient to supply all the inhabitants, and to resist the ravages of the dry seasons.

The appreciation of the people on the Isthmus was shown on July 4, 1905, when the water mains supplying the city of Panama were opened and the wholesale destruction of rain-barrels consummated. At a special session of the municipal council a vote of thanks was given the Canal Zone officials, and at the Cathedral a "Te Deum" was sung, which the President and his cabinet attended.

The efficiency of the mosquito reduction and the consequent elimination of the yellow fever are better known than is the remarkable falling-off of typhoid and dysentery. With a zone population increasing from 30,000 in 1908 to 40,000 in 1912 there was a falling off of dysentery cases of 50% and a reduction of typhoid cases among the employees of 80%.

Where the development of reservoirs was impracticable, due to topographical conditions, or where a temporary supply was needed, pending the completion of some piece of construction, a system of distribution arose, which might be used to advantage in northern construction camps with doubtful water-supplies. Old condensers and boilers were renovated and by means of these distilled drinking water was supplied at a cost of 1c. per gal. The water was delivered free of charge to all quarters and there put up in bottles and the precaution taken to disinfect not only the wagons, bottles, condensers and tanks, but the negro drivers as well.

Strange to say, the total reservoir capacity of over three billion gallons, supplying this narrow strip of jungle land 10 miles wide and 50 miles long, with a Panamanian city at each pole and with a total population of 130,000, is an absolutely inadequate protection against water famines. An enumeration of the chain of reservoirs giving this storage shows:

	Million gal.
Rio Grande Reservoir, supplying the city of Panama, and also the American settlements from Culebra to Ancon	496
As auxiliaries to the Rio Grande:	
A concrete storage tank on Ancon hill	.1
Cocoli Lake, which will later be submerged by the Miraflores Lake	429
The Camacho Reservoir, supplying from Empire to Las Cascadas	375
Supplying Gorgona, the Caribali Reservoir	160
Pumping plant supplying the smaller settlements from San Pablo to Frijoles with an unknown number of millions of gallons	
Agua Clara, supplying Gatun	613
Brazos Brook Reservoir, supplying Mt. Hope, Christobal and Colon	650
	2724

This is a material increase over the capacity of 1513 million gallons in 1908, which seemed then no more sufficient than do the three billion gallons today. At last the engineers in charge hit upon the idea of securing an

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unlimited supply by tunneling from the Brazos Brook and Rio Grande reservoirs to Gatun Lake.

The distribution of rainfall, runoff and evaporation, of course, governs the capacity of all reservoirs, and a comparison with some familiar northern example, such

FIG. 1. AGUA CLARA RESERVOIR, GATUN WATER-WORKS, PANAMA

as the Croton watershed, will show how these phenomena differ in the Tropics and make the problem there so unique. Fig. 2 shows the average monthly rainfall, runoff and evaporation at Colon and in the Croton watershed. The contrast is very noticeable. Considering first the rainfall: In Colon, 41 years of records show an annual precipitation of 149 in., of which only 11.36 in. falls from the last of December to the first of May. In 1911-'12, of the total 104.2 in. of rainfall, only 4.5 in. fell during the four dry months of the year. Contrasted with these statistics some specific instances may be cited:

	Record for	5 min.		1 hr.		24 hr
Colon	Aug. 1909	.64	Oct. 1909	4.9	Dec. 1906	8.53
Porto B.	Nov. 1911	2.48	Nov 1911	4.53	Dec. 1909	10.86

Thus while 1 in. per min. and 5 in. per hr. are often threatened in the rainy season, in the dry season 4.5 in. in four months may be expected to fall in perhaps 50 or 60 aliquot parts.

The above eccentric distribution has its important bearing on the percentage of runoff. For while the retaining power of the dense tropical vegetation maintains this runoff for a month into the dry season, the soil then becomes a veritable sponge. During the rainy season, however, all the vegetation becomes saturated and the runoff rises to 100%. The highest percentage occurs at the end of the season, with the heaviest rains, and produces freshets of the most violent sort. Measurements at Gamboa, one of the stations along the Chagres, indicate a rise of 33 ft. in 24 hr. and a subsidence of the same flood in an equal time. The discharge curve of Gatun Lake, with its drainage basin of 1320 sq.mi., rises from 0 to 34 billion cu.ft. during the four months of January to April and in the other 8 months from 34 to 237 billion cubic feet.

Allied with these extremes of rainfall and runoff is that of evaporation. (See Fig. 2.) The Brazos Brook station average shows that of the total evaporation of 51.51 in. per year, 22.59 in. occurs during the four dry months.

Though, doubtless, the evaporation is the major offender, it is true, especially at Brazos Brook, that there is considerable seepage from these reservoirs. The peculiar feature about this seepage is the fact that it has been more apparent in the natural hills surrounding these reservoirs than in the artificial embankments. Especially is this true where any of the earth blanket covering these hills has been removed. Whether this seepage is due to the general fissure structure, prevalent on the Isthmus, and the disintegration following the exposure of the metamorphized clay formation, is not absolutely known.

The lower elevation of the Brazos Brook Reservoir has placed the supply of Colon, Christobal and Mt. Hope in constant danger. Repeatedly have pumps been installed in the Mindi Diversion Channel to help tide over the end of a dry season, the filters been stopped because of their wash-water waste, and costly reliefs have been resorted to. The problem of increasing the capacity of this reservoir confronted the engineers in charge, but it was remembered that raising the dam 5 ft. in 1909 had caused

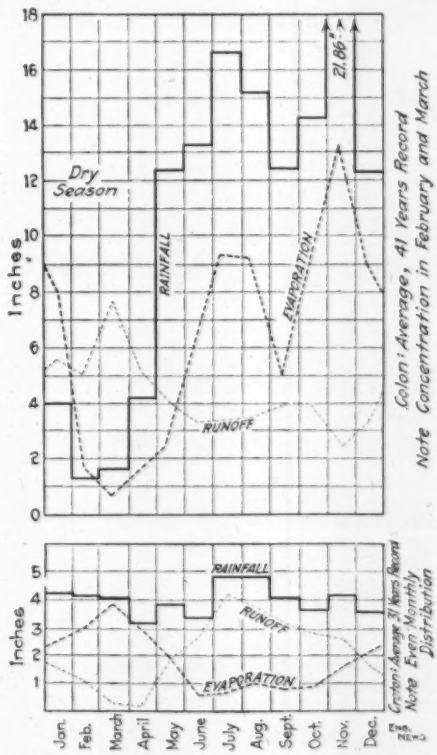


FIG. 2. COMPARISON OF RAINFALL, RUNOFF AND EVAPORATION AT COLON, PANAMA, AND IN THE CROTON WATERSHED, NEW YORK

excessive leakage through the surrounding hills, and though plans were again drawn to increase the height and put a clay bank on the reservoir side of the dam, still every effort was made to locate some other source of supply.

TUNNEL CONNECTION FROM GATUN LAKE

The idea was conceived of tunneling a connection from the Brazos Brook Reservoir to Gatun Lake and by this means keeping the water in the reservoir at a constant elevation of 48 ft. The tunnel was to run through the ridge separating the two watersheds, for a distance of 600 ft., and cross it at an elevation of 70 ft. above sea

level. Thus with Gatun Lake at a minimum elevation of 79 ft., the source of supply to the reservoir would be unlimited.

Though this procedure was at first objected to on the ground that the material passed through might prove troublesome because of slides, etc., and secondly because of the undesirability of making a cut through the hills below the general lake level, subsequent borings showed that the material was solid blue argillaceous sandstone of such density that water poured into the drill holes showed little absorption. The second objection was compromised by constructing the tunnel with a summit elevation of 75 ft. above sea level, instead of 70 ft. as first planned. This summit was itself 4 ft. below the minimum elevation of the lake and amply served the purpose.

Though this tunnel was the final solution, two other plans were considered. In one a main was to be laid over the lowest saddle, an elevation of 150 ft., and the water pumped over. The other was a siphon arrangement with the main laid inside a tunnel, having a summit 5 ft. above the high lake level. The cost of the latter system was estimated at $25,500 with an operating expense of $100 per month, while the estimated cost of the tunnel, as adopted, was $16,500, with no operating expenses.

The final design called for a 6x6-ft. excavation driven from both ends with a slight incline toward the center, so as to insure drainage outward. It was to contain the 20-in. main, which discharged into the reservoir 2½ miles from the dam. To obviate seepage and the consequent danger to the lake level, it proposed to seal the portals of the tunnel around the main with concrete, and possibly to imbed the main along its entire length, thus securing an additional strength and protection against rusting. This supply to the reservoir would insure a maximum supply to Colon, Christobal and Mt. Hope of 12 million gallons per day and in view of the 115 million gallons borrowed from Gatun during the water famine of 1911-'12, the expenditure for this relief was highly warranted. This same method of supply was adopted in the opening of 1913 to guarantee a sufficient supply to the Pacific division.

In conclusion then, the great loss due to evaporation and the loss unaccounted for, necessitate a reservoir storage capacity very much larger than that in northern climates. Very little relief can be expected during the four dry months of the year, even though nature has supplied a vegetation capable of a maximum retention of moisture. Lastly, the natural phenomena are the sole cause of this increased storage, because the consumption per capita, wherever metered, was found to be practically the same as that of the north, 100 gal. per capita per day, while the consumption for construction purposes has been considered in the calculations.

Effect of Extremes on Quality

The phenomena attending the above extremes of supply and consumption have also a very marked effect on the quality and the action of the water in the reservoirs and have led to the introduction of many interesting practices. These effects are in part due to the absence in the tropics of the seasonal "turnovers" of the water in storage reservoirs, common in the north.

In the Tropics, seasonal temperature changes are not sufficient to have any great effect on the current. The maximum atmospheric temperature is 97° F. and the minimum 60 and very rarely do sudden enough changes occur to cause an appreciable circulation. This continued high temperature reduces the oxygen saturation point, by decreasing the oxygen-containing power of the water, and allows organic matter in the bottom of the reservoir to attain an acme of putrefaction. It is true the wind and the atmosphere maintain an oxygen-bearing surface stratum varying from 7 ft. in the Cocoli Reservoir to 16 ft. in the Brazos Brook Reservoir, but the putrefaction conditions constantly increase throughout the dry season, and are disturbed only by occasional inrushes of cool, oxygen-bearing water from the heavy tropical showers. Such showers set up violent circulations and supply sufficient nitrates to permit a profuse distribution of "diatoms" throughout the entire reservoir and make unpalatable even that water drawn off near the surface. These "turnovers" are practically completed by the prolonged rains of the wet season. And not only is the northern practice of discharging the substratum through a "blowoff" followed at the beginning of the wet season, but excess water is almost always thus discharged, and disadvantages attend even this practice. So very putrefactive do these lower strata become that when the "blowoff" is closed the almost negligible current which has been generated is able to send a small amount of water into the upper oxygen-bearing stratum and decidedly taint the water at the intake. This might possibly be remedied by placing the "blowoff" some distance from the gate house.

The use of copper sulphate has been attempted, but it was found that a dilution by weight of one part to six million not only killed the algae, which were of the very delicate "anaboena" type, but killed a great many of the fish. No reason can be found for this action unless the constant high temperature produces a fish particularly susceptible to copper sulphate.

Odors due to the decomposition of vegetable matter are more prevalent, however, than those due to "algae." Gatun Lake in its recent rises has covered a great deal of timber land and land rich in decaying matter. So heavily has its water become laden with unoxidized organic matter that the discharge over the spillway at Gatun gives off an odor of hydrogen sulphide, which, liberated in its gaseous form, is sufficiently strong to destroy the paint on the neighboring houses and iron work and is offensive one mile away. This condition is a duplication of similar experiences with most of the reservoirs; all of them having been backed up over large areas to shallow depths, but, as in these other cases, it is believed that when the water has reached its final height the top layer will become oxygen-bearing and less objectionable. To guard against such putrefactive conditions the precaution was taken to place the intake of the tunnel from Gatun Lake to the Brazos Brook Reservoir at a normal of 10 ft. from the surface, taking at all times the best quality of water which the lake contained.

The necessity of drawing water from the upper strata is of the greatest importance. The Agua Clara Reservoir, with a spillway elevation of 60 ft., has five gate-house outlets, 9 ft. apart, varying from Elev. 59.5 to 23.5. This, of course, is entirely due to the fact that the presence of oxygen permits no reduction of organic matter, and the algae are largely confined to the bottom

of the reservoir. So greatly is the presence of oxygen appreciated, that additional aërating devices will be installed at the new purification plant at Mt. Hope to treat the water drawn from Gatun Lake. Effective relief has been obtained for a number of years at the various reservoirs by installing a boiler and air-pump at the gate-house and discharging air into the outlet pipe until a state of oxygen saturation was obtained. This method was resorted to when disagreeable tastes of "algae" growths were in evidence. It is noteworthy that though oxygen is essential to these minute vegetable organisms the effect of its violent introduction and the consequent agitation is harmful to their growth, as was shown some years ago by Whipple.

There is another reason why tropical reservoirs are so well adapted to the concentration of organic matter and the production of offensive odors. Besides the fact that the intense heat of the sun keeps the surface of the water at such a high temperature, and consequent lighter density, there is, as before mentioned, excessive concentration and settling during this period, due to the increased consumption and evaporation, and the negligible replenishing of the water.

The effect of this settling is shown by samples taken at the surface and at the bottom of the reservoir in February, the midst of the dry season. The bottom sample was very much higher in color, free and albuminoid ammonia, total solids and iron, while the surface water was relatively free from organic matter and bacteria. This concentrated settling, which continues until broken by the sudden floods of the wet season, produces still greater seasonal variation. The alkalinity, as shown by the accompanying tables, increases from 26 to 50%; the total solids from 9 to 30%; and the chlorine rises as high as 40%. In the instance of Brazos Brook, a marked increase of color, accompanied by a corresponding increase of iron, from 0.1 to 2.0 parts per million, proved to be a verification of the northern idea, that color is very largely due to the iron content. In fact, coagulation and chemical sedimentation were there necessitated by the superabundance of iron, which, together with the vegetable matter, clogged up the pressure filters after a run of two hours. This element also encouraged the growth of that aquatic plant, sometimes encountered in the North and known as the "crenothrix," which has repeatedly clogged iron house connections so that they had to be replaced.

With the approach of the rainy season a great change comes over the reservoir. The heavy rains wash down many soil and pathogenic germs, some of which, not being native to water, soon die, while others settle into the lower strata. This is illustrated by the prevalence of B. coli in samples taken after rainstorms. Subsequent examination of samples of neighboring soils showed B. coli to be so frequent there that its occurrence in the water samples was considered less a "typhi" than a run-off indicator. The abundance of rain also serves to dilute the water in storage so that the alkalinity, chlorine, total solids, and iron content reach a minimum at the close of the rainy season; but the organic content increases, because of the wash from the dense vegetation surrounding all the reservoirs.

The following table gives analyses taken at the end of the rainy season, or period of greatest dilution, and again at the end of the dry season, or the period of greatest concentration:

Samples Taken at the End of the Wet Season

Reservoir	Rio Grande	Comacho	Carabali	Brazos Brook
Color	30	20	25	23
Alkalinity	45	54	62	28
Chlorine	1.2	1.5	3.0	3.5
Oxygen consuming power	4.3	3.8	3.7	4.3
Nitrogen as				
Free ammonia	0.047	0.043	0.028	0.027
Albuminoid	0.231	0.214	0.388	0.324
Nitrites	none	none	none	none
Nitrates	trace	trace	trace	0.7
Total solids	103	111	137	90
Loss on ignition	41	46	47	48
Iron	0.3	0.1	0.1	0.1
Bacteria per c.c.	950	1900	3300	13,500

Samples Taken at the End of the Dry Season

Color	20	15	25	100
Alkalinity	67	73	61	30
Chlorine	4	4	6	5.5
Oxygen consuming power	4.1	4.2	6.5	5.3
Nitrogen as				
Free ammonia	0.072	0.064	0.180	0.292
Albuminoid	0.200	0.408	0.428	0.456
Nitrites	0.003	trace	0.003	0.003
Nitrates	none	none	trace	trace
Total solids	113	115	139	89
Loss on ignition	26	29	35	37
Iron	0.2	0.3	0.3	2.0
Bacteria per cc.	130	250	300	3500

Variations, such as those above described, made filters the price of safety. For though, in general, the reservoir waters were of good quality and reasonably low in suspended matter and bacterial count, the sudden disturbances, which entirely unbalanced this quality, required the safety afforded by filters.

Mechanical Filtration

The first filter installed on the Isthmus was of the mechanical-pressure type, consisting of 8x20-ft. cylinders, through which pumps forced the water with a loss of head of 5 lb. per sq.in. As before mentioned, the heavy iron and organic content so quickly clogged these filters that chemical precipitation with sulphate of alumina was resorted to. The plant for this preliminary treatment consisted of two 2100-gal. chemical solution storage tanks, a 7500-gal. mixing tank and two 50,000-gal. settling tanks.

The results, though fairly efficient, became more and more unsatisfactory, because of the high unit cost and the fact that it was necessary to waste 4% of the filtered water in washing.

The table shows the results obtained with this plant for the twelve months of the year:

Benefiting by the experience gained in the operation of the Mt. Hope plant, considerable study was put into the design of the new plant to be built at the Agua Clara Reservoir, for the supply of Gatun. It consisted (Figs. 3 and 4) on following page of a 70x70-ft. by 10-ft. deep settling basin, which was preceded by a mixing-box, provided with grids for introducing the aluminum sulphate and perforated pipe for the forced injection of oxygen. The filter house contained four 17x17-ft. filters of the rapid-gravity type built up of 30 in. of sand and over one foot of sandstone gravel, each with a normal capacity of 825,000 gal. There were also two solution tanks 9x9 ft. by 7 ft. deep and a covered clear water well 12½ ft. deep, of a 200,000 gal. capacity.

The plant differed from the old one at Mt. Hope in the arrangement of the settling basins, in an efficient mixing tank, the introduction of air, and in working by gravity instead of pressure. The practice with this plant does not differ materially from the same process in the "States," except for the additional aëration precautions which are necessary. Coagulant equivalent to 1.5 grains

per gal. is added and a three-hr. settling period used. The settling basins, which have 12-in. drains and a slope of 1 ft. in 20, are cleaned once a week. The hydrate flushes out very easily when handled by two men with a hose under pressure. The new filter saves 30 to 35% of the waste wash water over that of the old pressure plant and has a sufficient bacterial efficiency, inasmuch as all natives have been removed from the watershed.

One point worthy of note is that the engineer in charge claims that it is possible to get a satisfactory reaction without the addition of lime as long as the alkalinity remains above 5 parts per million. Except when the clay acts as absorptive to the hydrate before it has time for coagulation with the water—a theory advanced some time ago by G. W. Fuller—1 grain of the sulphate is equivalent to about 8 parts of alkalinity. Thus for ordinary treatment the alkalinity content would have to be at least 12 p.p.m. for treatment without lime. This feature of Isthmian practice is difficult to explain, because the turbidity of the raw water rarely exceeds 50 p.p.m.

The table at the bottom of the page shows the results obtained from this filter, for the short period it has been in operation.

It has now become necessary to replace the obsolete pressure filter at Mt. Hope. It is interesting to note in what way it is intended to change and improve the practice in this new plant, inasmuch as the gravity filter at Gatun has been in operation long enough to permit definite conclusions regarding it.

The new plant is to be of the rapid mechanical gravity type with a normal daily capacity of 6 million gallons. Not only is air to be forced into the water during its passage through the mixing box, but a special aeration chamber is to be built. The plant otherwise differs from the one at Gatun only in that it will provide for an 8-hour settling period instead of a 3-hour. It is believed, from past experience, that this additional aëration will result in the saving of 15% of aluminum sulphate.

The cost of this plant is $18,000 per million gallons capacity as compared with $16,300 at Gatun, the additional cost resulting from the increased aëration and sedimentation facilities and the fact that the plant is built on a pile foundation. Plans prepared for the mechanical pressure type showed the daily cost of fuel oil, necessary to force the water through the filter at 10 lb. per sq.in., at $3130 per year, which represents an 8% saving on the additional cost of the gravity type.

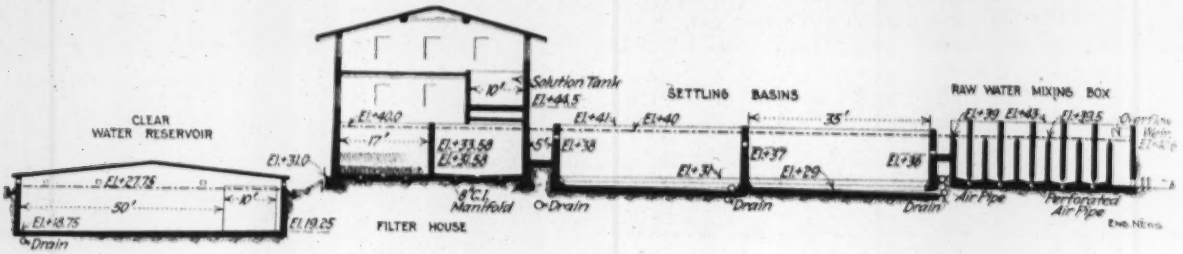


FIG. 3. NEW WATER-PURIFICATION PLANT FOR GATUN, PANAMA

In the design of Isthmian filter plants, the question naturally arises, why the cost of chemicals at such a distance from the market does not make their use prohibitive; also, in view of the low turbidity—15 in the dry season and 35 in the wet—and low bacterial count, why should not the use of slow sand filters be ideal. Other facts which point in the same direction are that sand can be transported to the site for about $1 per cu.yd. and abundant acreage is available, for all the territory belongs to the government. This combination of circumstances doubtless influenced visiting sanitary engineers in 1910 to recommend the slow sand filter.

In 1911 a number of experiments were carried on to find out the qualities of the various sands within reach.

MOUNT HOPE FILTER AND BRAZOS BROOK RESERVOIR

Month 1911	Rainfall, in.	Elev. reservoir, ft.	Alkalinity, per million raw	Alkalinity, per million filtered	Coagulant aluminum sulphate	Turbidity, per million raw	Turbidity, per million filt'd
July	14.03	43.7	17.0	7.0	13,175	15	0
August	12.19	43.4	16.0	3.0	15,655	20	0
September	10.33	43.0	17.0	2.0	15,750	23	0
October	14.43	45.0	18.0	1.0	17,360	20	0
November	18.81	49.9	17.0	6.0	12,000	25	0
December	1.86	46.2	18.0	5.0	14,260	20	1
1912							
January	0.58	43.1	18.0	4.0	18,600	20	0
February	2.26	40.6	19.0	7.0	18,125	12	0
March	1.25	37.3	18.0	7.0	19,590	15	0
April	0.81	33.5	18.5	8.0	12,515	20	0
May	13.37	32.5	19.0			30	
June	18.12	35.9	19.2			25	
	108.04				156,970		

Month 1911	Color, per million raw	Color, per million filt.	Odor, per million raw	Odor, per million filt.	Bacteria per c.c. raw	Bacteria per c.c. filt.	Million gallons of wash water	Million gallons of consumption
July	35	10	0	0	695	68	8.421	78.597
August	27	8	0	0	781	75	8.143	76.004
September	25	4	1	1	693	109	8.032	74.871
October	38	5	2	0	596	116	8.440	78.775
November	35	2	0	0	691	88	8.430	78.681
December	30	20	0	0	598	65	9.149	85.394
1912								
January	45	5	0	0	476	154	9.552	89.149
February	58	7	0	0	498	179	8.809	82.219
March	30	0	0	0	502	192	9.967	93.027
April	30	0	0	0	900	200	9.767	93.027
May	45	Earthy			650		7.182	67.030
June	45		0		1110		6.884	64.247
							102.766	959.156

AGUA CLARA FILTERS AND RESERVOIR

Month 1912	Rainfall, in.	Elevation reservoir	Alkalinity, per million raw	Alkalinity, per million filtered	Aluminum sulphate*	Turbidity per million, raw	Turbidity per million, filt.
January	0.75	60.6	25	28	3,266	30	
February	2.10	58.2	26	17	3,109	28	0
March	0.36	55	33	17	2,707	20	0
April	0.27	51.25	32	30	3,609	50	0
May	13.47	49.90	35	26	3,697	30	0
June	16.25	54	46	26	12,000	20	0
July	13.50	59.20	35	26	1.2	5	0
August	12.6	61.8	29	17	1.3	2.5	0
September	18.62	63.3	28	17	1.4	2.5	0
October	17.64	67.7	28	18	1.5	10	0
November	17.65	68	33	19	1.4	10	0
December	8.1	68.1	33	19	1.6	10	0
	121.31						

Month 1912	Color raw	Color filt.	Odor raw	Odor filt.	Bacteria per c.c. raw	Bacteria per c.c. filt.	Million gallons of wash water	Million gallons of consumption
January	75	5	0	0	469	129	1.219	16.460
February	70	8	0	0	436	160	1.161	15.670
March	75	8	0	0	469	119	1.516	20.462
April	60	0	0	0	800	150	1.709	23.073
May	35	0	earthy	0	550	150	1.604	21.651
June	35	0	0	0	798	101	1.914	25.834
July	35	0	0	0	983	299		81.995
August	25	0	0	0	925	161		87.099
September	30	0	0	0	1028	215		80.266
October	40	0	0	0	935	187		85.196
November	35	0	0	0	928	121		84.855
December	40	0	earthy	0	1021	198		86.490

*Aluminum sulphate is given in total pounds, January to June, and gr. per gal., July to December.

In nearly every case, the sands were unsuitable for water filtering purposes because of their fineness, high content of calcareous matter, or the cost of transportation. The Chomé sand, used by the Pacific division for construction purposes, was the least objectionable. It had an effective size of 0.38 and a uniformity coefficient of 1.2 and though

FIG. 4. GENERAL VIEW OF WATER-PURIFICATION PLANT FOR GATUN, PANAMA

it was delivered to the Pacific division storage pile at 80c. per yd., cost $22 per yd. when screened and in place in the filters at New Gatun. Thus the high cost of sand, the reasonably low cost of sulphate, and the low bacterial count threw the advantage in favor of the rapid gravity type with chemical precipitation.

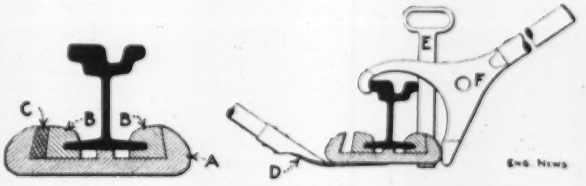
The most marked difference between filter-plant operation on the Isthmus and that of similar plants in the North has proved to be the great importance of aëration. Though experiments in the North have shown that the addition of large quantities of oxygen, to water which already had a high content, had little or no effect on the organic matter present, the difference in efficiency effected on the Isthmus was very appreciable and was probably due to the effect of this free oxygen on the iron content of the water. For the iron in a ferrous state changes into an insoluble ferric precipitate on contact with free oxygen. This conclusion is borne out by a study of the above analyses. The old Mt. Hope pressure plant with no aëration facilities and its high color in December, January and February, the dry months of 1911 and 1912, gave an effluent high in color, despite the fact that from 20 to 60% more sulphate was used during these months. In contrast, the Agua Clara plant at Gatun with 50% higher color in the raw water, gave a decidedly higher efficiency in color removal, by means of its aëration facilities.

In conclusion, the problem of water-supply on the Isthmus must be regarded as the most interesting and important feature of sanitary work encountered there, with the possible exception of the mosquito work; and it is of greatest importance to the success of the latter. The natural phenomena, so eccentric in their nature, produce very unusual concentration and putrefaction and demand large storage capacities, for such a moist climate, and produce extreme variations in the chemical constituents of the water. In addition, the heavy organic content washed down by the extreme rains, running off over the dense tropical vegetation, together with the great concentration of iron, make the introduction of oxygen a matter of extreme importance.

A Rail-Joint of the Wedge Type*

Several forms of rail-joints of the wedge type have been used in Europe, and a joint of this type which has been used to some extent on steam and electric railways in Austria has the peculiar feature of being heated before its application. The base of the joint consists of a cast-steel shoe (*A*) of channel section, with a central rib upon which the rail rests. On each side is a steel block (*B*), having its face grooved to receive the rail base. The block on the inner side bears directly against the face of the shoe, but on the outer side there is room for a horizontal taper key or wedge (*C*), which is driven home to form the fastening. The joint is used both with and without ordinary splice bars bolted to the webs of the rails.

The application of the joint requires a gang of six men, with an equipment of sledge hammers, a gripping lever, a coke brazier, an iron shovel or hoe and a hook for handling the hot base-plate, and a jack frame for applying the side blocks. With old rails there may be also a device for straightening the rail ends. The blocks are first fitted to the edges of the rail base, and then the jack frame is set across the rail, with the jaw on one side bearing against one of the blocks and the head of the jack screw against the jaw which bears upon the other block. By turning the screw the blocks are forced home upon the rail. The heated shoe (*A*) is then put in place under the joint by means of the shovel (*D*), and while the inner end is held up by the hook (*E*) another man holds the rail and shoe together by the gripping lever (*F*).



AN AUSTRIAN RAIL JOINT OF THE WEDGE TYPE

The wedge (*C*) is then inserted and driven home, a sledge hammer being held against the opposite side of the shoe to keep the latter square across the rail. The bearing faces of the shoe and blocks are ground with emery, and the shoe is cleaned with a wire brush when taken from the heater. After the joint is completed and the shoe is cool the rail heads are ground to remove any irregularity of surface. This joint is manufactured by Scheinig & Hofmann, of Linz, Austria, and is patented in this country.

A Heavy Industrial Locomotive, for use on the 36-in. gage tracks at the Ensley steel works of the Tennessee Coal, Iron & Railroad Co., was noted in our issue of Sept. 4, and we have received recently from this company some further particulars of the engine. The reason for using such a heavy locomotive for the yard work at Ensley was that two of the smaller engines (97,000 lb. on driving wheels) were required to handle a heat from the openhearth furnaces to the mills, and at times this was accomplished with difficulty and attended by more or less delay. The new engine handles these loads without any difficulty and has reduced the repairs to the equipment to a minimum. The sharpest curves are of 96 ft. radius, and the maximum grade is 1%. The engine will haul 615 tons gross, or 26 loaded mold cars, with 1500-lb. drawhead pull, developing 39,000 lb. tractive power on level track.

*A French joint of this type was described and illustrated in our issue of May 27, 1909, but that joint gripped both the base and the web of the rails.

The First Diesel Locomotive

About two years ago, it was announced that the famous European firm of machinery builders, Sulzer Bros., was coöperating with Dr. Rudolph Diesel, of Munich, in the design and construction of a railway locomotive to be operated by Diesel oil engines.

The advent of the Diesel oil engine as a motive power for marine transportation has been probably the most important event in mechanical engineering since the development of the steam turbine. At least it has attracted the widest attention in all European countries. The task of applying the Diesel engine to locomotive propulsion is one of very much greater difficulty, and much interest has been felt as to the manner in which the many difficult problems would be worked out. The first public information regarding the Diesel locomotive was given by Dr. Diesel himself in his lecture before the American Society of Mechanical Engineers, during his visit to this country a year ago last spring. He gave at that time, however, only a diagrammatic elevation of the locomotive, with a brief statement of the general principles on which it was designed. Practically the same information was given in the patent issued to Sulzer Bros. at about the same time.

During the present year, the locomotive has been completed and put into trial service, and we are indebted to the courtesy of Sulzer Bros., of Winterthur, Switzerland, for a description, drawings and photograph of the machine, which are presented herewith. It may be surmised at the outset that the German Government, in accordance with its well known policy of fostering the development of important German inventions, has probably cooperated in the production of the locomotive, for it is stated that the new machine was ordered by the railway department at Berlin for the Prussian-Hessian state railways.

The organization formed to build this locomotive and presumably to control the construction of future locomotives on the same type, is the Thermo Locomotive Co. In this company are associated the firm of Sulzer Bros., of Winterthur, Switzerland and Ludwigshafen, Germany, Oberbaurat A. Klose, of Berlin, and Dr. Rudolph Diesel,

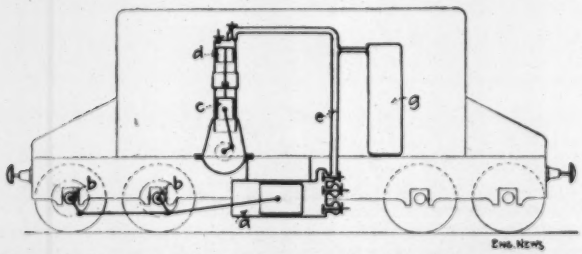


FIG. 1. DIAGRAM ILLUSTRATING GENERAL PRINCIPLE OF OPERATION OF DIESEL OIL-ENGINE LOCOMOTIVE

of Munich. The headquarters of the Thermo Locomotive Co. are at Ludwigshafen. The patents on the new locomotive, however, are owned by Sulzer Bros. The running gear of the locomotive was built by the well known locomotive constructor, A. Borsig, of Berlin. The principal work on the design of the locomotive has been under the direction of Oberbaurat A. Klose. The machine was erected in the Sulzer Bros.' works at Winterthur, and the Diesel engine equipment, etc., was constructed there. The locomotive was given its first trial run on the line from Winterthur to Romanshorn, and was taken to Berlin at the end of March, 1913, running by way of Basel, Strassburg, Worms and Nordhausen. It made speeds during this trip of 20 to 100 km. per hour. Since its delivery, it

THE FIRST DIESEL OIL-ENGINE LOCOMOTIVE

has been given further trial runs on the Berlin-Mansfeld Ry. The following description of the locomotive has been furnished to us by Sulzer Bros.

The motive power of the locomotive is a Diesel oil engine directly coupled to the driving axles, and an auxiliary Diesel engine which is completely independent of the driving axles but drives an air compressor. The latter has a power one-fifth to one-fourth that of the driving engine and the compressed air it produces operates the driving engine in starting, on heavy grades, etc., with long cutoffs. The auxiliary engine delivers its compressed air to storage reservoirs which can supply air for starting when the auxiliary machine is idle, and also furnish an additional supply when the demands are greater than the auxiliary engine can supply.

Fig. 1 shows diagrammatically the arrangement of the driving and auxiliary engines (German patent to Sulzer No. 205,995); a is the driving engine coupled to the driving axle b, which in accordance with the requirements of locomotive operation is reversible; c is the auxiliary engine. This drives the air compressor d which furnishes high-pressure air through the pipe e to the driving engine a. The air can be used there as starting air or as injection air.

In starting the locomotive, the auxiliary engine c is kept in operation and continuously supplies compressed air for

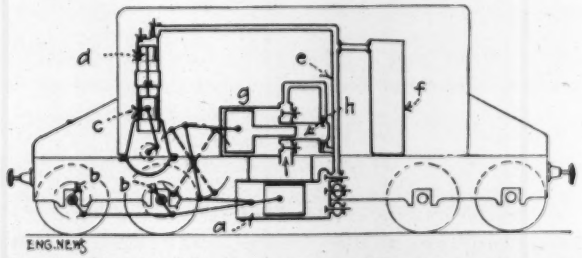


FIG. 2. DIAGRAM ILLUSTRATING A DIFFERENT ARRANGEMENT OF THE DIESEL LOCOMOTIVE

starting to the driving engine, supplemented as required by additional air from the reservoir g. The compressed-air operation is continued until the train attains a velocity of 8 to 10 km. per hr. Then the main engine is changed to use liquid-fuel, and thereafter works according to the normal constant-pressure cycle.

The locomotive may also be arranged in another manner. Instead of relying solely on the compressed air furnished by the auxiliary engine, the driving engine may also have compressors connected to it. Fig. 2 shows the latter arrangement in diagrammatic representation. (German patent No. 223,425). Here a is the driving engine coupled with the driving axles b; c is the auxiliary engine which drives the

compressor d. By means of a walking-beam the driving engine operates a pump g which at normal output can be used for supplying air for charging, scavenging and injection.

The actual arrangement of the locomotive now completed is shown in Fig. 3. As there shown, the main driving engine is a reversible four-cylinder single-acting Sulzer two-cycle motor. The four working cylinders are arranged in V shape and each pair of cylinders have their axes at 90° with each other and work on a common crankpin, the connecting rod being forked. The two cranks are 180° apart so that balanced action is secured and at a speed of 100 km. per hr. make 304 r.p.m. The engine cylinders are 380 mm. in diameter and 550 mm. stroke (about 15x22 in.) The crank axle, which has three bearings in the cast steel box-shaped frame (which is fitted between the frame plates and is connected with the cylinders and covers by columns), carries

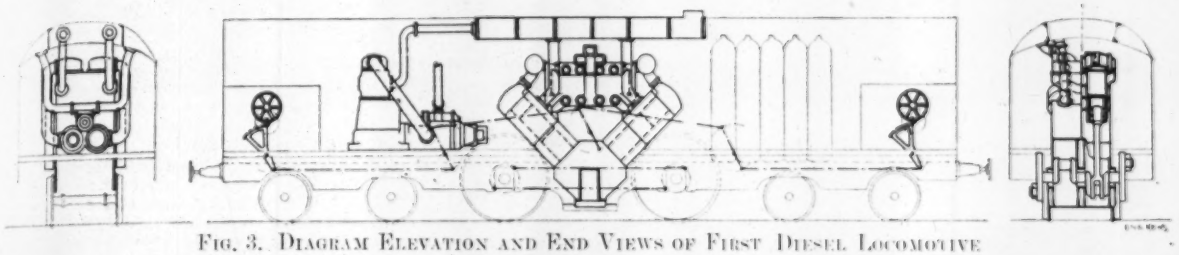


FIG. 3. DIAGRAM ELEVATION AND END VIEWS OF FIRST DIESEL LOCOMOTIVE

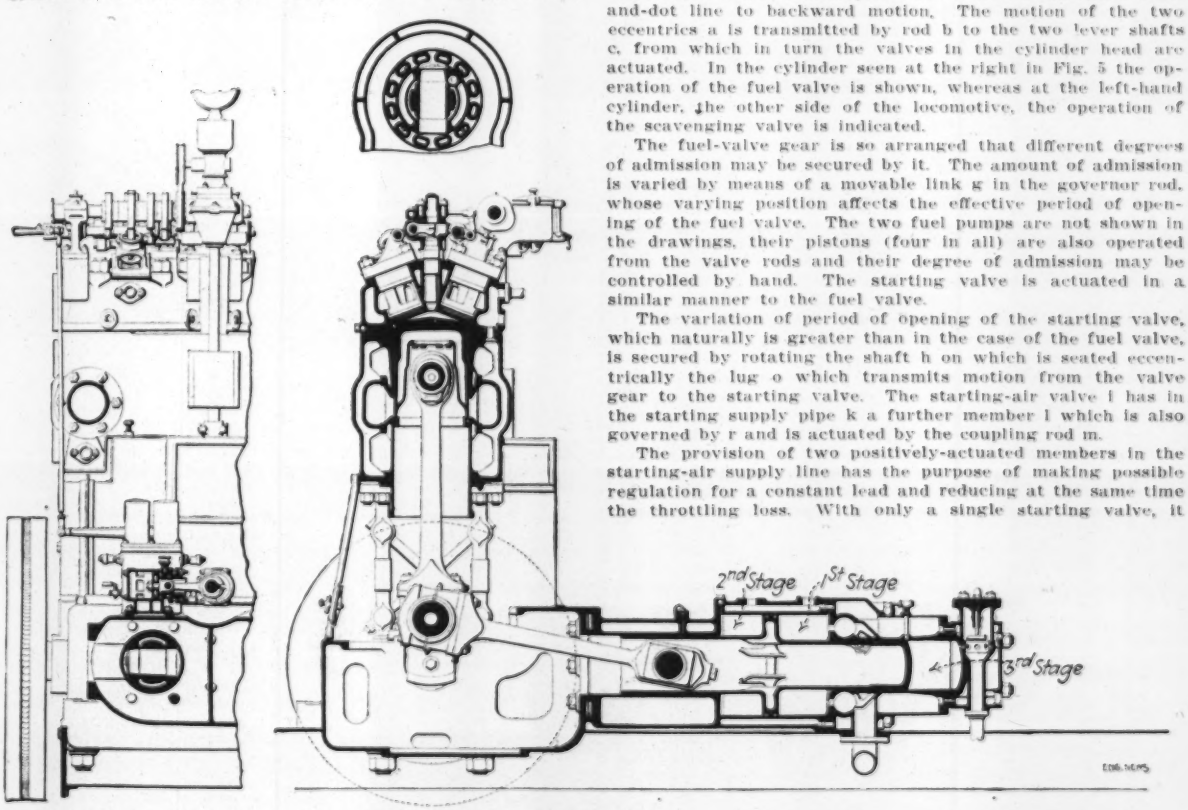


FIG. 4. MAIN DRIVING ENGINES OF DIESEL LOCOMOTIVE

besides the two working cranks also two crank disks with counterbalance weights, pressed on the shaft. These cranks rotate the driving axles by connecting rods.

In this arrangement (covered by German patents Nos. 210,385 and 199,220) there is a complete balance between the primary forces of the reciprocating masses of the working cylinders and the centrifugal forces of cranks, coupling rods and balancing weights. Of course the driving wheels also contain balance weights for the rotating masses in the crankpins, etc.

The secondary forces of the driving engine masses are unbalanced, but give a resultant of horizontal direction acting in the central plane of the crankshaft and thus having no effect at right angles to th plane of the track or to cause nosing.

Each cylinder head, as shown in Fig. 4, carries a fuel valve, a starting valve, and two scavenging valves. The injection air has a pressure of 50 to 70 atmospheres, the starting air of 50 atmospheres and the scavenging air of 1.4 atmosphere absolute. The exhaust passes through ports in the cylinder walls which are opened and closed by the piston. Between the crank disk and frame are seated two eccentrics, each of which actuates the valves of half of the machine. The eccentrics may be rotated to reverse the motor when the locomotive is to run in the opposite direction. This operation is performed by special rods d, a, f, shown in Figs. 5 and 6 on following page. The position of the lever e shown by a full line corresponds to forward motion; the dash-and-dot line to backward motion. The motion of the two eccentrics a is transmitted by rod b to the two lever shafts c, from which in turn the valves in the cylinder head are actuated. In the cylinder seen at the right in Fig. 5 the operation of the fuel valve is shown, whereas at the left-hand cylinder, the other side of the locomotive, the operation of the scavenging valve is indicated.

The fuel-valve gear is so arranged that different degrees of admission may be secured by it. The amount of admission is varied by means of a movable link g in the governor rod, whose varying position affects the effective period of opening of the fuel valve. The two fuel pumps are not shown in the drawings, their pistons (four in all) are also operated from the valve rods and their degree of admission may be controlled by hand. The starting valve is actuated in a similar manner to the fuel valve.

The variation of period of opening of the starting valve, which naturally is greater than in the case of the fuel valve, is secured by rotating the shaft h on which is seated eccentrically the lug o which transmits motion from the valve gear to the starting valve. The starting-air valve i has in the starting supply pipe k a further member l which is also governed by r and is actuated by the coupling rod m.

The provision of two positively-actuated members in the starting-air supply line has the purpose of making possible regulation for a constant lead and reducing at the same time the throttling loss. With only a single starting valve, it would be difficult to design the valve gear for constant lead at all stages of cutoff, occurring in the present case between the limits zero and 68%. There would also be considerable loss at the throttle valve in the unavoidably slow opening and closing. These disadvantages are avoided by the construction of the double valve gear as described (German patent No. 248,381).

The leading valve is actuated in an always constant manner—constant in time as well as in lift—by a fixed lug on the valve shaft.

It is characteristic of this valve gear that the lines of

symmetry of all lift curves of the main valve seated in the cylinder head fall on the same radius. This insures on the one hand that on dead center the main valve will be completely lifted at all points of cutoff so that the air admission always occurs at the dead-center point, by means of the leading valve; and on the other hand that in applying this valve gear to the reversible engine, reversing of the main valve is unnecessary and the direction of rotation of the engine is changed merely by reversing the leading valve, without sacrificing susceptibility to control in the starting gear.

Between the four working cylinders of the driving engine there are two double-acting piston compressors and alongside these a three-stage compressor for the injection air. All three pumps are driven from the two connecting rods of the two front working cylinders by means of levers and connecting rods.

The injection-air pump forms a reserve for the auxiliary-engine air pumps. When the auxiliary engine for any reason becomes inoperative, the injection-air pump is capable of furnishing sufficient injection air at normal speed provided the driving engine is not under excessive load.

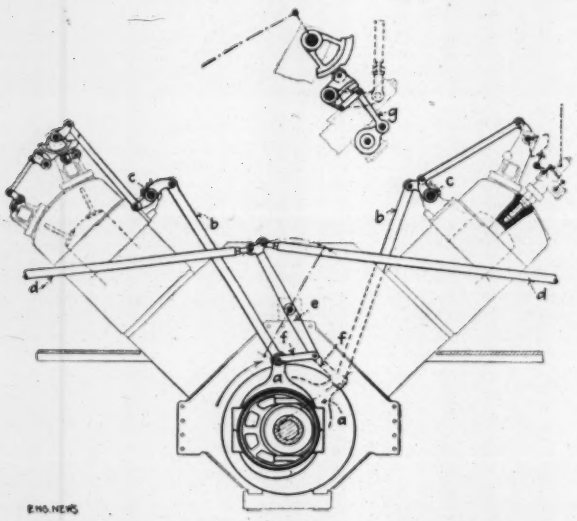


FIG. 5. VALVE-GEARING OF MAIN DRIVING ENGINE, DIESEL LOCOMOTIVE

The air delivered by the three-stage compressors of the auxiliary engine is cooled in an intercooler above the machine after each pressure stage. From the high-pressure cooler the air is led to a distributor and from here, according to demand, is distributed to the point of use by opening of a valve. One pipe line goes to the starting-air reservoir, another to the injection-air reservoir already mentioned, a third to the reserve reservoir. The latter again communicates through the distributor with the auxiliary engine to start it. The injection-air reservoir is also connected through the distributor with the auxiliary engine, to furnish the air needed for spraying the oil. At each engineer's position there is a starting head with two valves which serve to connect the driving engine with the starting-air reservoir and with the injection-air reservoir.

The exhaust head for muffling the exhaust of the two engines is located in the cab roof over the driving engine. It consists of three pipes lying side by side, and divided by perforated plates into several spaces.

The working cylinders and partially also the air-pump cylinders are served by a special lubricating pump. The quantity of lubricating oil can be controlled separately for each cylinder. All crankshaft and connecting-rod bearings, as well as all parts moving in the crank case, are supplied by pressure lubrication, oil being taken from the crank

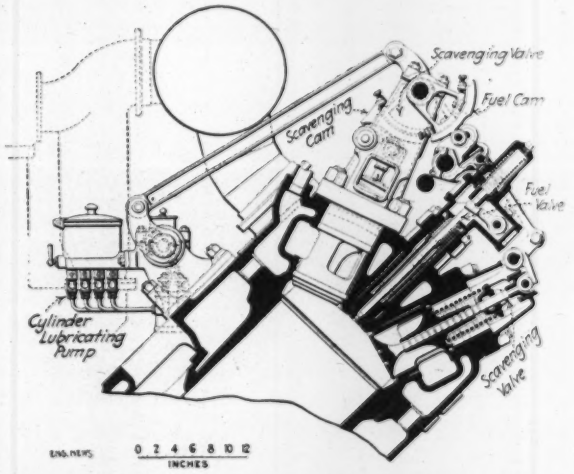


FIG. 6. SECTION THROUGH CYLINDER HEAD OF MAIN DRIVING ENGINE, DIESEL LOCOMOTIVE

The auxiliary engine is also a two-stroke cycle Diesel engine and is rated at 250 b.hp. It has two vertical cylinders of 305 mm. bore and 380 mm. stroke (about 12x15 in.) and is supplied with fuel by a fuel pump with two pistons. The two cranks of the motor, 180° apart, also take the connecting rods of the two horizontal multistage air pumps.

For a particular position and spacing of the driving and compressor cylinders, of this auxiliary engine the primary forces are completely balanced by counterweights in the flywheel. The secondary forces of the compressors are specially counterbalanced in so far as they are of injurious effect.

The pump stages lying nearest the crankshaft furnish the scavenging air for the two driving cylinders. The next stage of each pump is the low-pressure, and the third the middle and high-pressure stage for the high-pressure air used as starting and injection air. The control of the scavenging air and the admission of the low-pressure air are taken care of by a rotary valve. By means of a distributing valve the output of the compressor can be changed as desired from zero to the maximum value.

The governor, which controls the output of the fuel pump and depending upon its spring tension gives the machine a speed of from 200 to 350 r.p.m., is seated upon the vertical valve-gear shaft. This drives the horizontal camshaft which in turn operates the entire valve gear. On the crankshaft there is on each side of the machine a flywheel. A switching arrangement serves to connect the motor in starting position. By the starting mechanism the starting and fuel valves are brought within reach or beyond reach of their cams.

When the driving engine is out of operation or is consuming little air, the auxiliary engine delivers its compressed air into a reservoir behind the driving engine.

chamber, filtered, and forced through pipe lines to the individual points of lubrication.

There are three pumps for circulating the cooling water, one a double-acting circulating-water pump, another a cold-water pump, and the third a piston-cooling water pump. A fourth pump handles the fuel.

The circulating-water pump, which like the cold-water pump is controlled by a circulating cock, forces the water through the different pipes and thence to the evaporator. In this the water emerges from four pipes through small holes which offer a resistance to the flow of the water, and then returns to a tank from whence it goes to the suction of the circulating pump.

On the pressure side of the circulating pump the water required for cooling the piston is abstracted and is sprayed into the hollow piston by the nozzle-shaped end of the pipe. The returning water is again carried back into the stream of the circulating water.

The fuel-supply pump, built as a part of the cooling-water pumps, takes fuel from two tanks in the car and discharges it to a filter from where it flows to the fuel pump. The excess fuel flows back to the tank.

In the engineer's cab there are four hand pumps, of which the first is built into the cold-water line, the second into the circulating line, and the third into the fuel suction line, so that these pipes can be filled after having been emptied even when both engines are standing. The fourth pump communicates with the lubrication of the driving engine, so that when the locomotive is standing still the operative parts in the crank case can be lubricated.

On both sides of the locomotive the pipe lines are brought together, so that all cooling-water spaces and pipes can be readily emptied.

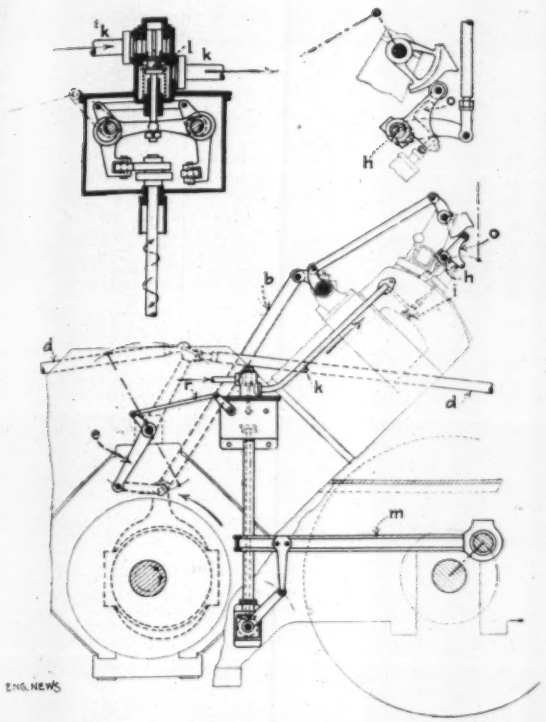


FIG. 7. DRAWING SHOWING OPERATION OF STARTING GEAR WITH ENLARGED DETAILS

At each end of the locomotive there is a cab in which the operating mechanism of the control and reverse gear and the following appliances are fitted: levers for throwing in and out of gear the starting and fuel valves, the lever for controlling the fuel-oil pumps, the starting head, the engineer's brake valve with sander, the whistle, and the different gages.

Getting ready for running comprises the operations of starting the auxiliary engine and throwing in the starting-air valve. The starting-air valve in the starting head is first slowly opened. Air then flows from the starting reservoir to the starting valves of the engine. The air pressure slowly rises and the engine begins to turn. The degree of admission determined by the starting valve is gradually reduced as the pressure rises. When a speed of about 10 km. per hr. is reached the starting-air valves are thrown out of action and the fuel valves are opened. The locomotive then is in normal operation and according to speed and power demand the cutoff of the fuel pump and the pressure of the injection air are regulated.

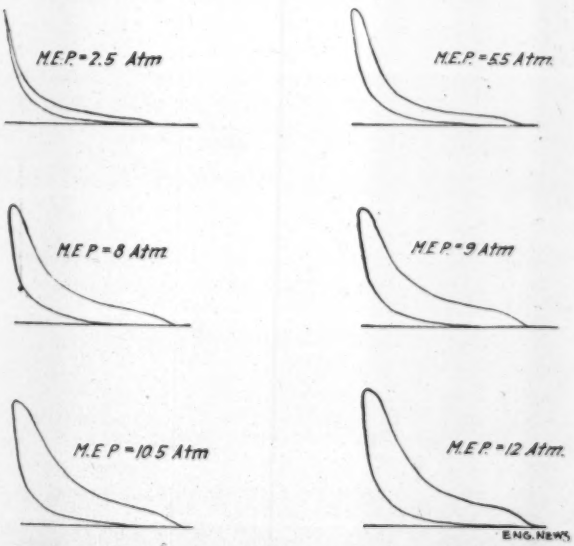


FIG. 8. INDICATOR DIAGRAMS FROM DIESEL LOCOMOTIVE

To stop the engine, the fuel valves are closed and the brake valve is actuated. The engine is reversed by turning the handwheel in the engineer's cab so that the valve gear is changed to backward running. There is an interlock which prevents reversing while the fuel valves are open.

In starting, stopping and during running the same manual operations are required for backward as for forward motion.

The test run on the Winterthur-Romanshorn had the purpose on the one hand of permitting the Diesel motor to be studied in its utilization for locomotive driving, and in the second place of permitting a study of starting, changing over from compressed air to fuel operation, and reversing. A few indicator diagrams taken during the test run on the Winterthur-Romanshorn line are reproduced in Fig. 8. They illustrate the great variation in power developed made possible by the construction above described.

The locomotive has a length of 16.6 m. (about 55 ft.) over end buffers, and its service weight is 95 tons. The coupled driving axles have a wheel base of 3.6 m. (about 12 ft.).

The driving wheels are 70 in. diameter.

The engineer's cab, over the machinery, is continued over the whole length of the locomotive. In the four corners are tanks, at one end for cooling water and at the other for cooling water and fuel. The exhaust head is in the center over the driving engine and over the cab at one end is a "beehive" cooler and over the other an "evaporation" cooler for the jacket water.

⁂

A Simple Rule for Inflating Pneumatic Tires was given recently by the service manager of one of the tire companies, and is applicable to tires of all sizes. According to this rule the front tires should be inflated to a pressure in pounds equivalent to 17 or 18 times their cross-section in inches and the rear tires to 20 times their cross-section, thus 34x4-in. tires should have a pressure of about 70 lb. on the front wheels, and 80 lb. on the rear.

Tests of Automobile Pumping Engines were run under the direction of the Committee on Exhibits, International Association of Fire Engineers, during the 41st annual convention of the association, held in New York City, September, 1913. The approximate capacities of the engines submitted for test were determined at preliminary trials. The conditions of the final test were as follows:

(1) Six hours' run at not less than full capacity, at not less than 120 lb. net pressure, pumping through three lines of hose and one nozzle. (2) Three hours' run at not less than half capacity, at not less than 200 lb. net pressure, one line of hose and one nozzle. (3) Three hours' run at not less than 250 lb. net pressure, one line hose and one nozzle. The engines will draft from the Hudson River, with an average lift of 10 ft.

There were 11 entries, of engines with capacities ranging from 600 to 1400 gal. per minute. The following readings were taken and an hourly average for each was determined: (1) pump pressure; (2) nozzle pressure; (3) gallons per minute. The official records of the test show that only three of the engines remained in continuous operation throughout the test (12 hours). Some difficulties were experienced during the first three hours. In the next five hours only a few minor troubles developed; but during the ninth hour two engines were withdrawn, the first due to hot bearings, the second to water-hammer. The ninth hour seemed to be the critical period as regards endurance, for from that time on serious difficulties were experienced. In the tenth hour another engine was shut down on account of leaky valves; in the eleventh a fourth was stopped because of a broken fire pump bearing, and motor trouble. At the conclusion of the twelve-hour run, seven engines were still in service and with the exception of two were maintaining the required pump pressure of 250 lb.; the first of the latter was operating at 192 lb., the second at 249 lb.

The engines tested, and their capacities at 120 lb. pressure, were as follows: (1) Seagrave, 1000 gal.; (2) Ahrens Fox, 700 gal.; (3) American-La France, 1400 gal.; (4) Knox, 600 gal.; (5) Robinson, Jumbo, 750 gal.; (6) Nott, 800 gal.; (7) Waterous, 700 gal.; (8) American-La France, 700 gal.; (9) Luitwieler, 600 gal.; (10) Nott, 600 gal.; (11) Robinson, Monarch, 900 gal. The first seven engines were operating at the end of the test; of these, 8 and 9 were below the required pressure of 250 lb., while of the other five, 1 and 11 experienced the least difficulty. The remaining four engines withdrew in the following order: 9, 10, 11, 8.

Track Inspection Car; Erie R. R.

As an aid to the maintenance of railway track in good condition, a most useful machine is the dynagraph or track-inspection car, which detects irregularities and imperfections and not only makes autographic records of the track conditions in diagram form, but also marks defective points by spots of colored liquid ejected upon the track. Such a machine was introduced many years ago by P. H. Dudley, now Consulting Engineer of the New York Central Lines, and has been used extensively by him in inspecting and reporting upon rail and track conditions on numerous railways. Similar machines are now being used by some railways in their own regular work, for the benefit of the operating service and the maintenance-of-way work. One of the latest of these has been introduced on the Erie R.R., particularly with a view to ascertaining track conditions in regard to the safety of high-speed trains, and for the comparison of these conditions with track standards.

The car is 60 ft. long over end sills, and 66 ft. long over platforms; and it is carried on six-wheel trucks. It

FIG. 1. INTERIOR OF RECORDING ROOM ON TRACK INSPECTION CAR; ERIE R.R.
(On the table in the middle of the car is the traveling sheet of paper, with the stylographic pens resting upon it.)

is arranged on the general plan of a business car, and has sleeping accommodation and limited cooking facilities. The rear portion of the car forms an observation room 23½ ft. long, in which is mounted the recording apparatus, together with gages and other equipment. This room opens upon an observation platform. The car is equipped with heating apparatus and electric light. It was built and equipped according to designs prepared under the direction of the mechanical department of the railway company, and for plans and other information we are indebted to Mr. Schlafge, General Mechanical Superintendent, Erie R.R.

RECORDING APPARATUS

The apparatus for the detection of track irregularities is designed to indicate automatically (by the ejection of colored liquids upon the roadbed) imperfections of track alignment, and to make autographic records of the following conditions: (1) longitudinal and transverse irregularities of track surface; (2) variations in gage; (3) cross level and car swings; (4) lurches; (5) speed and distance traveled; (6) time (in 5-sec. intervals).

Variations or fluctuations in track condition are recorded in the usual way upon a moving strip of paper by means of stylographic pens. The pens are arranged in two sets. In one of these the pens are stationary, establishing a series of horizontal datum lines on the paper. The other pens have a motion at right angles to these lines. The motion is imparted and controlled through the various mechanisms for detecting track imperfections, and varies with the extent of these imperfections. As the paper moves under the pens at a rate directly proportional to the speed of the car, indications of track irregularities will appear in their true relation and can be located at any time as may be necessary. Fig. 1 shows the observation room, with the table and pens of the recording apparatus.

THE TRACK SURFACE RECORDING DEVICE

The purpose of this apparatus is to provide means for the detection of low-joints and unsatisfactory conditions of track surface in a longitudinal direction, and such defects are indicated by the vertical movements of the central axle of a six-wheel truck relative to the outer axles. This is shown in Fig. 2.

The mechanism consists of a 6-in. I-beam (*A*) mounted over each side sill of the truck, supported at the ends by stanchions (*B*) fastened to the front and back journal boxes. On the middle journal box are bolted two plates (*C*) outside and inside of the pedestal. These plates are free to move vertically in yokes attached to the I-beam, and their movements in a vertical direction relative to the beam are transmitted to the recording apparatus by means of a phosphor-bronze wire carried on brass sheaves. This mechanism is applied to each side of the truck and indicates simultaneously the defects of both rail surfaces.

Two sets of adjustable electric contact points are provided on each of the outside plates (*C*), fastened to (and moving with) the middle journal boxes, and are arranged to make connection with corresponding contacts carried on the I-beams. Whenever a variation of track surface amounting to ⅜ in. or over is encountered, one set of points makes electrical contact and the condition is automatically registered by means of a counting mechanism. In a similar manner, all irregularities of ⅝ in. or more are registered by the other set of contact points. The points are suitably connected in series with the car storage batteries and counting apparatus on the car. It is provided further that when either a ⅜-in. or ⅝-in. variation in surface alignment is registered, an electro-pneumatic spotting valve ejects a colored liquid upon the roadbed by the pipe (*D*), thereby marking the location of the defect.

TRANSVERSE SURFACE

To detect transverse irregularities (that is, in the surface of the opposite rails) which cause objectionable side swings to the car, a heavy pendulum is provided. This swings in a plane transverse to the track, and is immersed in oil to damp its movements and prevent the disturbing effects of sudden lurches and minor vibrations. When passing curves, the action of centrifugal force

upon the pendulum is counterbalanced by an adjustment in the recording-arm connection, so that the pen makes a true record of the condition of the track as to transverse surface.

General Imperfections and Car Lurches

A more sensitive pendulum (also swinging transversely to the track) is used to detect minor vibrations

Fig. 2. Track Surface Recording Mechanism on Track Inspection Car; Erie R.R.

(The I-beam (A) is carried by stanchions (B) on the end axle-boxes. The plates (C) on the middle axle-box slide in guides on the I-beam, indicating the vertical movements of this axle in relation to the end axles, and making electric contacts with the recording mechanism. Through the pipe (D) paint is ejected to mark defective points in the track. The small wheel (E) is part of the gage-recording mechanism.)

and sudden lurches of the car due to various imperfections in the track. This pendulum carries two copper balls, each secured to the end of a light band-steel spring, which in turn is fastened at one end to the pendulum blade by an adjustable screw clamp. The copper balls are thus free to vibrate at the end of steel springs held in a vertical position and parallel with the pendulum. A sudden car lurch produces a corresponding motion of the pendulum. This motion, transmitted to the copper balls through the flexible steel springs, causes one of them to fly out and make electrical connection with suitable contacts.

The pen which registers lurches of the car is electromagnetically operated, and when the copper ball makes a contact the continuous line being recorded by this pen is notched, the notch constituting a record of an objectionable track condition causing the lurch. An electric counting mechanism and electro-pneumatic spotting valves are also wired in series with the recording apparatus, so that each defect is counted automatically and is marked on the track with a colored liquid.

Gage-Recording Device

Variations in gage are detected by means of a pair of small wheels on an axle behind the rear truck, as shown in Fig. 3 and at (*E*) in Fig. 2. The wheels slide on the axle and are held against the rails by springs, so that they follow all variations in gage. These variations are transmitted to the stylographic pen of the recording apparatus by means of a phosphor-bronze wire and suitable sheaves and levers. This axle is raised in a guide frame when not in use, and the wheels are then drawn slightly inward (to a gage of 4 ft. 8 in.) by means of a spiral clutch, so that when lowered they will fall inside the gage of track. The movement of the axle is effected by pneumatic apparatus controlled from a three-way valve in the car.

Speed, Time and Distance Indicators

An electric-contact time clock is connected in circuit with the datum-line pens, and is so arranged that each five-second interval is registered by a notch. As the movement of the record paper is proportional to the distance traveled, these notches in the datum line serve as a means to determine train speed.

The locations of mile-posts, stations, bridges, etc., are recorded electrically by an observer, who presses a key as the car passes such points. These indications constitute an accurate method whereby the position of track imperfections can be located, and provide a check upon the operation of the track-spotting device.

Operation of Track Inspection Car

The apparatus has been found reliable at train speeds of 3 to 40 mi. per hr., according to track conditions, but at higher speeds the cross-level and lurch devices are affected by the movement of the car and the centrifugal force when rounding curves, so as to give inaccurate results. The apparatus is calibrated, therefore, for a speed of 35 mi. per hr., and that speed is maintained as nearly as possible when the car is making records. Before placing the car in service, the various detecting and recording mechanisms were carefully calibrated upon a section of specially prepared track. As all the devices are provided (where necessary) with suitable adjustment facilities, it

Fig. 3. Trailing Axle and Loose Wheels for Recording Variations in Gage; Track Inspection Car; Erie R.R.

is anticipated that track-inspection work can be performed and accurate records obtained covering a wide range of conditions.

The Building Charge on the Huntley Irrigation Project, Montana, has been fixed by the Secretary of the Interior at $50 per acre for lands in private ownership filed on after Dec. 1, 1913. The sum named is to be paid in installments as follows: $10 the first year; $1 the second, with increases of $1 a year up to the 5th year; then $5 a year for the next four years and a final payment of $10. The operation and maintenance charges on all water-right applications made after Aug. 12, 1913, will be $1 a year whether the water is used or not. This yearly payment will entitle the water user to one acre-foot of water per acre of land irrigated. Additional water will be furnished at the rate of 50c. per acre-foot.

Hydraulic Laboratory for Irrigation Investigations, Fort Collins, Colo.

By V. M. Cone*

In many sections of the irrigated West, water is rapidly becoming so valuable as to necessitate a more accurate division among the several canals appropriating from any one stream as well as among the individual irrigators under each canal. This condition is comparable to the transition period through which many municipal electric and water companies have passed when changing from the old flat rate to a meter charge. However, economic conditions, as well as the relatively large volumes of water to be handled, prevent the use of the ordinary type of water meter. There is such an urgent demand for correct information on the measurement of water for irrigation purposes that it was found advisable to conduct a large number of experiments with various measuring devices to determine their accuracy and supply correct formulas for same. Lack of suitable facilities for conducting such hydraulic research led to the construction of a special laboratory at Fort Collins, Colo., under a cooperative agreement between Irrigation Investigations of the Office of Experiment Stations, U. S. Department of Agriculture, and the Colorado Experiment Station. This laboratory has been in operation since the last of May, 1913, and several seasons will be required to complete the investigations now outlined.

The laboratory was proposed in the spring of 1912, and an unsuccessful search was made in the vicinity of Fort Collins for a readily accessible site on a stream with a dependable water-supply and ample fall. A hillside location was finally chosen on the campus of the Colorado Agricultural College, the water-supply being obtained from the city mains (see Figs. 1 and 2 for view, plan and sectional elevation of laboratory). Since the maximum demand is about 20 cu.ft. per sec. it was necessary to provide a storage reservoir on the top of the hill. This reservoir has a bottom diameter of 72 ft., a depth of 6½ ft., side slopes 1 to 1, and a plain concrete lining 4 in. thick, with radial expansion joints filled with grade C asphaltum. All concrete water surfaces throughout the plant have a ⅜-in. cement plaster coat, mixed 3 to 1.

Three circular headgates, 6, 12 and 18 in., respectively, in diameter, allow the water to pass from the storage or head reservoir into a concrete headrace or channel, where

FIG. 1. HYDRAULIC LABORATORY FOR IRRIGATION INVESTIGATIONS, FORT COLLINS, COLO.

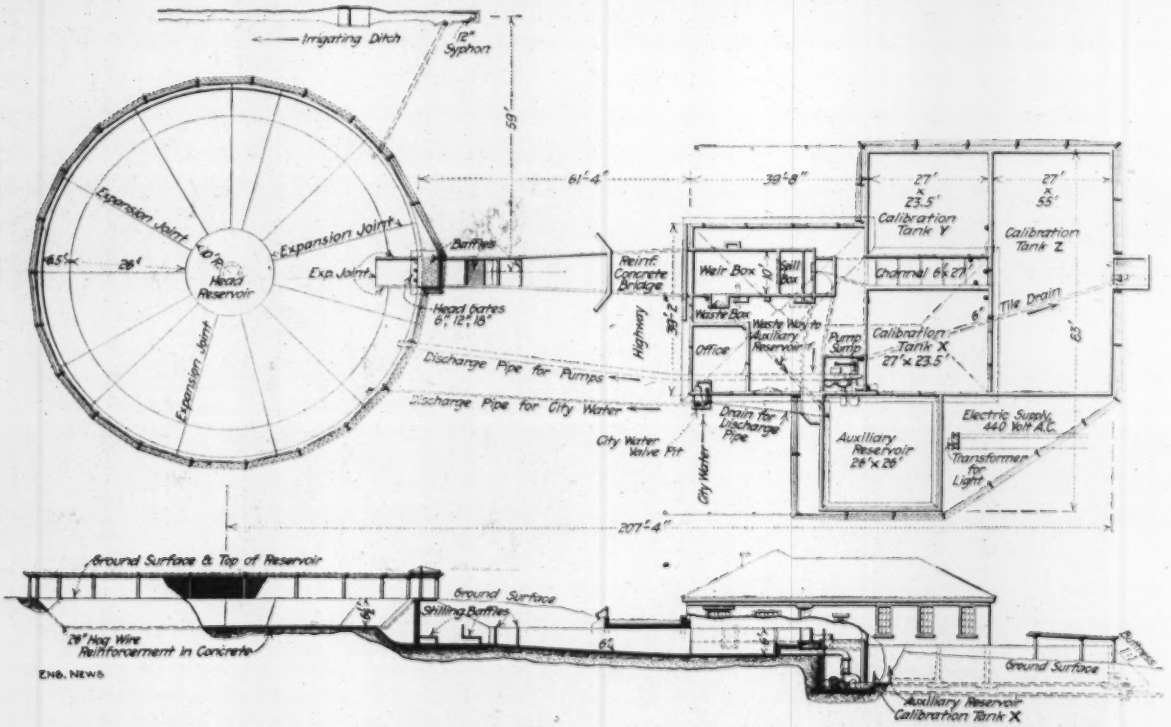


FIG. 2. PLAN AND SECTIONAL ELEVATION OF HYDRAULIC LABORATORY FOR IRRIGATION INVESTIGATIONS, FORT COLLINS, COLO.

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it is stilled by a series of horizontal and vertical baffles. This headrace gradually enlarges from a cross-section of 6 ft. wide by 4 ft. deep to 10 ft. wide by 6 ft. deep at a distance of 60 ft. from the headgates, and the weir box proper is an extension of the headrace for another 20 ft., but with a uniform cross-section. The top of the weir box and headrace wall is level and at the same elevation as the bottom of the storage reservoir. A tee-iron frame about 6 ft. long by 3 ft. deep is set in an opening in the end of the weir box, and by means of bolts and flat rubber gaskets, orifice and weir plates to a crest length of 4 ft. may be installed. From the weir the water spills into a concrete box the full width of the weir box, 9 ft. long and 4 ft. deep, in which there is an arrangemnt of adjustable flashboards for submergence work on the measuring devices. A double shear gate, having two 22-in. circular openings with but one disk, permits the water to be turned into either of two separate channels leading to the calibration tanks and an auxiliary reservoir.

The calibration tanks may be best described as though one reservoir 55 ft. square had been divided into half by a wall, and normal to this wall in one half two walls had been built so as to make a channel at the center 6 ft. wide, leaving a tank 23½x27 ft. on either side. The water drops into the channel and may be let into any or all of the tanks by 14-in. circular gates placed at the floor line. These tanks are 8½ ft. deep, with floors at the same elevation. They are of reinforced concrete, floors 6 in. thick, side walls with a batter of 8 in. at the top to 14 in. at the floor line, and division walls 12 in. thick. The walls were designed as retaining walls and as bins or tanks, and all the water faces are vertical. The auxiliary reservoir, which is used only for waste water, is 26x26x8½ ft., with the batter on the water face.

The water is returned to the head reservoir from the auxiliary reservoir and calibration tanks by a 5-in. horizontal centrifugal pump, direct-connected to a 7½-hp. motor, and a 12-in. horizontal centrifugal pump, silent chain driven by a 35-hp. motor (see view, Fig. 3). The large pump has a twin suction to permit water to be drawn from either the auxiliary reservoir or calibration tanks as desired. The small pump is only for the return of waste water from the auxiliary reservoir. Both pumps are placed in an 8x9-ft. dry-concrete sump 18 in. below the floors of the tanks, to make them self-priming. They have a common discharge into a 16-in. riveted-steel pipe which leads over the top of the coping of the head reservoir. This arrangement demands only low-pressure gates on the suction openings, without any check valves. The electrical control is on the main floor of the laboratory.

A brick building, with trussed roof and unfinished interior, covers the weir box, pump sump, and one of the calibration tanks and channel, having maximum dimensions of about 39x67 ft. A concrete floor was placed 1 ft. above the top of the calibration tanks, which is also 3 ft. below the top of the weir box. The waterways are carried under the floor, the concrete being placed on corrugated-steel arches. In one corner of the building is an office room where instruments and records are kept and certain computations are made.

A few of the operating details of the laboratory may be of interest. In many experiments with weirs and orifices it is essential that a constant flow of water be maintained throughout the test, which is commonly 40 minutes, and practically the entire storage-reservoir supply is used for an individual test. The decreasing head in the reservoir calls for a more accurate regulation than can be secured from the reservoir gates. For that reason adjustable spillways were provided in the weir box. One over-pour spillway resembles a door 2 ft. high and 3 ft. long, hinged at the bottom and placed in the side of the weir box. This is raised or lowered by a screw arrangement. There is also a common 4-in. gate valve leading from the weir box to permit of finer regulation. This waste water is led to the auxiliary reservoir by an 8-in. tile placed under the laboratory floor. By always running a fair volume through the spillways the head in the weir box can be kept at a constant height by giving or taking. Boyden type hook-gages are installed in concrete stilling boxes both above and below the weir. The spillways are controlled by the upper hook-gage observer. He also directs the operator of the storage-reservoir gates by means of an electric-bell signal system.

Preliminary to starting an experiment the shear gate is set to throw the water into the auxiliary reservoir. When the desired head has been obtained in the weir box,

FIG. 3. PUMPING PLANT, HYDRAULIC LABORATORY, FORT COLLINS, COLO.

(Looking down from laboratory floor; vertical discharge pipe shows in top center.)

the shear gate is thrown practically instantaneously and the water passes into the calibration tanks and the test begins. The time is taken from a gong attached to the lever of the shear gate. In a similar manner, the water flows into the auxiliary reservoir at the conclusion of a test until the flow is shut off at the storage reservoir. This prevents complications due to accelerating flow.

A 1-in. round brass rod 9 ft. long is placed in a vertical position in each calibration tank, being held about 6 in. from the wall by brackets which are set in the concrete (Fig. 4). At intervals of about 18 in. on the rods are holes which serve as data points. A heavy brass clamp fixed to the back of a hook-gage is provided with a pin which snugly fits the hole in the rod. But one such portable hook-gage is therefore needed for all the tanks in order to determine the water-surface elevation in any tank. Calibration tables have been prepared which show the quantity of water in any tank for all data points and the full range of the hook-gage. This permits of working from a water level for both initial and final measurements. The actual volume of water run during an experiment is determined by differences. To facilitate reading the hook-gage, steel ladders (Fig. 5) were placed adjacent to the brass standard rods, and are anchored to

the concrete. A 20x24-in. platform, with brackets which hook onto the ladder rounds, may be placed above the water surface for the observer. Attached to the platform is a funnel-shaped arrangement which may be adjusted to form a stilling basin for the hook when there is wave action in the tank.

The calibration of the tanks was obtained in a rather unique way. About 0.5 ft. out from each corner in the floor of each tank a brass plug was set in the concrete. The four plugs in each tank were so set as to form a rectangle as nearly as possible. Through a hole drilled diagonally through the top of each plug a piano wire was run to the top of the reservoir, made taut, and carefully plumbed. Distances between wires on sides and diagonals were taken through several elevations with a standard tape. The volume of this rectangular solid was then

FIG. 4. TAKING WATER ELEVATION IN ONE OF THE CALIBRATION TANKS BEFORE STARTING A TEST, HYDRAULIC LABORATORY, FORT COLLINS, COLO.

determined by pairs of triangles in each horizontal plane, giving a check on the accuracy of the measurements. A thread having markers each 2 ft. of its length was then stretched between the wires and the distances taken from the wall to the thread with an accurate scale. Such measurements were made through each foot of elevation and the volumes of the slabs were computed and added to the volume of the main rectangle for each unit elevation. Although entailing considerable work, both in taking the measurements and computing same, the method gave the desired accuracy.

Inclosed types of low-head water meters can be tested from a 12-ft. flanged pipe placed in the side of the weir box above the floor line. Such devices, as well as headgates, short pipe, and other practical irrigation outlets, can also be tested between bulkheads placed in the channel of the calibration tanks. Five sets of channel irons, spaced 5 ft. apart, were set in the sides and bottom of the channel to permit bulkheads to be installed when needed.

Outside of the calibration tanks is a 12-in. pipe connection to permit of testing tile, pipe and similar materials where a length of several hundred feet is desired. At this point is also a 6-in. valve connected to a drain line in order that the tanks may be drained and cleaned and filled with fresh water every few weeks.

The entire present season is being devoted to weir ex-

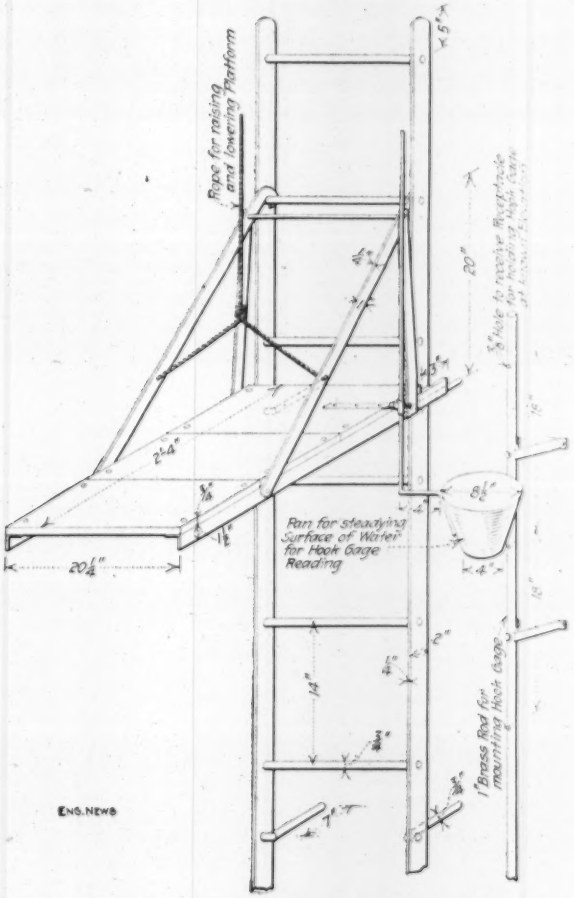


FIG. 5. LADDER AND PLATFORM FOR USE IN DETERMINING WATER SURFACE IN CALIBRATION TANK, HYDRAULIC LABORATORY, FORT COLLINS, COLO.

periments, because the weir is generally considered to be the standard measuring device for flow in open channels. Many engineers who have had to deal with the measurement of water have encountered discrepancies in their results of such a nature as to indicate fundamental error in the weir formulas. Most new measuring devices have been calibrated by being hitched in tandem with a weir, thereby incorporating the inaccuracies of the weir table, together with the innate defects of the new device, in the formulas derived. This procedure has led to complications, and it was deemed advisable to start the research work in the new laboratory with weirs as the fundamental basis.

A word concerning the reasons for performing these experiments may not be amiss. A considerable part of the formulas for the flow of water is the product of mathematical effort rather than the result of experiment. Theory and practice are sometimes at variance. Some formulas have been derived from experimental data secured by quite indirect methods and therefore liable to be in error. Other formulas were obtained from direct

quantitative or volumetric experimentation and, though that work was performed many years ago, at a time when knowledge of the laws of the flow of water was even more limited than at present and instruments and apparatus not as desirable as those obtainable today, still the results indicate a very nice accuracy. The fault does not lie in the work but rather with subsequent extrapolation and application of those data. Many of the experiments were with large weirs for power purposes and doubt is attached to any justification for applying those data to weirs much smaller than those used in the experiments. The division of water among irrigators especially calls for weirs much smaller than those used for power purposes. Furthermore, limits for the application of empirical formulas have been specifically stated by the experimenters, but such qualifying or cautionary statements have been lost in the transfer in abridged form from volume to volume.

The results to be obtained from all work in this hydraulic laboratory will be made available to the public through bulletins of the Colorado Experiment Station, or the U. S. Department of Agriculture, and it is confidently expected that some data will be ready for publication before many months.

A Hand-Operated Bascule Bridge

While much has been published in regard to large and important drawbridges, there is comparatively little information available as to drawbridges of the smaller class, although such information may be fully as interesting and valuable as that relating to the large bridges. In ENGINEERING NEWS of July 18, 1912, there were described some small hand-operated vertical-lift drawspans, and a hand-operated highway bascule bridge was described in our issue of July 24, 1913, in an abstract of a paper by Lewis E. Moore, of Boston.

This latter article, however, did not deal with the gearing for operating the bridge, and as this is a matter of interest, we give herewith a diagram and brief description of the gearing, from information furnished us by the designer, as supplementary to the original paper. We may note that the drawspan is a plate-girder structure, of 36-ft. span, and that the girders are extended back of the trunnion to carry a concrete counterweight which forms a part of the roadway of the approach span when the bridge is closed.

Upon one of the trunnions is keyed a quadrant, having an operating rack which is driven from a train of gearing on the fixed span. The train is operated by a crank handle describing a circle of 16-in. radius, and the proportions of the gears are as follows:

	Pitch diam., in.	No. of teeth	Pitch, in.
Pinion (A)	4 1/2	14	1
Spur wheel (B)	29 1/2	93	1
Pinion (C)	4 1/2	14	1
Spur wheel (D)	35 1/2	113	1
Pinion (E)	6 1/2	12	1 1/2
Quadrant rack	72	72	1 1/2

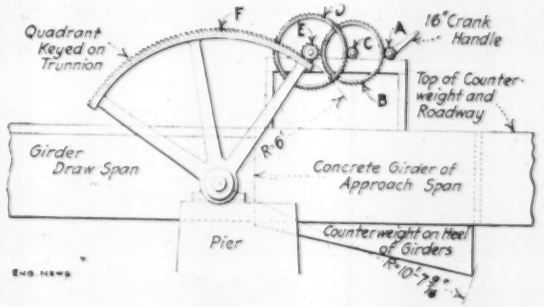
In regard to the operation, it was assumed after some estimating and trial, that a turning moment of 20,000 ft.-lb. would be required to handle the draw, and the train of gearing is designed so that a man can exert this moment by using a force of 8 lb. on the crank handle. One man can open the draw with one hand in four minutes.

The end lock does not act in the way mentioned in the description of the bridge (in our issue of July 24), the hooked lock-rod having been fitted by the builder in a horizontal position (projecting from the end floor-beam) instead of in a vertical position, as designed. Mr. Moore states that this was probably because he did not supervise the work and give detailed instructions.

The estimated weights of the bridge are given us by Mr. Moore, as follows:

Flooring	13,200 lb.
Wooden stringers	4,230 lb.
Floor beams and brackets	3,800
Laterals	700 lb.
Two girders	8,000 lb.
Total	30,020 lb.
Counterweight	85,000 lb.

A curious and rather objectionable feature of the design is that the counterweight forms a portion of the roadway of the adjacent fixed span, and as the bridge swings up the counterweight swings down, so as to leave an opening about 10x15 ft. in roadway. This seems to be a decidedly dangerous arrangement, especially as there



GEARING FOR OPERATING A 36-FT. BASCULE BRIDGE BY HAND

is no gate to close the roadway when the bridge is open, while even a gate would serve probably to exclude teams only, and not pedestrians. In dark or stormy weather, or in the event of a crowd being attracted upon the bridge, this unprotected opening might be a point of danger. The omission of a gate was due to the desire to save expense in every possible way.

State Foresters are now employed by 22 of our states, including Hawaii.

The Reconstruction of the Sibley Bridge, carrying the Atchison, Topeka & Santa Fé Ry. over the Missouri River at Sibley, Mo., has been completed as far as the main river portion is concerned. The bridge was built in 1887, and the reconstruction work to adapt it to heavier loading was described in our issue of Feb. 15, 1912. The steel work of the new bridge is completed from the west end of the structure clear across the main river. This includes all of the truss spans and the west approach viaduct. There is still to be erected, however, the steel viaduct across the east bottoms, about 2000 ft. This will not be completed, probably, until February.

The designing of the new bridge was not especially difficult. The key to the whole proposition was the handling of the work in the field under traffic. The track across the east approach viaduct now stands on an ascending grade (westbound) of 0.8%. This same grade extends nearly two miles east of the end of the steel viaduct. The second track embankment is being built across this stretch, and the grade reduced to 0.5%. The track at the east end of the viaduct will be raised nearly 7 ft. and the grade across this reduced to 0.5%. All of these features make rather interesting and possibly somewhat troublesome work in the field.

The contract for the substructure work, falsework and steel erection is in the hands of the Missouri Valley Bridge & Iron Co., and all the steel is being furnished by the American Bridge Co. The work is under the direct supervision of A. F. Robinson, bridge engineer of the A., T. & S. F. Ry. System.

Recent Photographs of the Panama Canal Work

Notwithstanding all that has been published concerning the great earth slides on the banks of the Culebra Cut at Panama, it is extremely difficult for the average reader, and even for the engineer, to form a mental picture of what one of these great earth slides looks like. Of the great number of photographs of the slide that have been taken, almost all fail to give a true representation of the appearance of a slide, partly because of the extent to which the camera fails to show the true relation between elevation and distance and because of the difficulty of recording in a photograph, the slight differences of light and shade which are apparent to the observer on the ground. The two photographs, here reproduced, give the best idea of one of the big slides at Panama of any photographs we have ever seen. The slide shown is the famous Cucaracha* slide, located just south of Gold Hill, the highest point along the line of the Culebra Cut. This slide was the one which gave the greatest trouble to the French engineers in the '80's, when the work under De Lesseps was most active. Soon after the work under the Americans began, in July, 1905, this great slide began moving again, and over 3,000,000 cu.yd. had been excavated from it up to July 1, 1912. At the date of the last annual report, a year ago, the slide had been quiescent for about a year. In his report dated July 20, 1912, the Chief Engineer of the Central Division, Col. Gaillard, said that the Cucaracha slide "gives no evidence of any considerable future movement." During the past year, however, the slide has been again in motion and as seen by the photographs, this movement has continued this fall, since the construction tracks were removed from the cut. The total area of ground on the slopes of the hillside involved in the Cucaracha slide is 47 acres.

It will be evident that one of the first tasks to be undertaken by the huge ladder dredges when water is admitted into the cut, and they are brought into it and set to work, will be the digging away of the material in this great slide. The photographs also aid the reader to understand how futile are the various projects proposed by engineers and others who have never been on the ground, for the prevention of such slides. Various schemes of this sort were actually tried by the French engineers in De Lesseps' day. Large concrete storm-water channels, for example, were constructed to carry away the surface water from above the slide and prevent its percolation into the ground. This plan has worked admirably in certain soil and in certain climates; but it proved as useless in checking the motion of the great earth masses at Panama as the attempt of the old lady to sweep back the Atlantic Ocean with a broom.

Another photograph here reproduced shows a pair of the great lock gates completed and closed; and is especially notworthy because of the clearness with which the photograph shows the riveting on the face of the gate. It will be noted that the hand railing on the top of the right-hand gate has been erected, while that on the left gate is just being put in place.

Another photograph in the series shows the emergency dam at the head of the Pedro Miguel lock, completed and in position. These structures have already been described in detail in the columns of ENGINEERING NEWS; but the photograph makes the general construction very easily understood. The dam structure is carried by a swingbridge, the turntable for which is placed on one side of the lock chamber. The longer arm of this bridge, carrying the dam structure, is counterbalanced by a heavy weight on the shorter arm, which swings over the land. When the canal is in use, the swingbridge is placed parallel with the lock chamber, leaving the channel clear. In order to put the dam in position, the bridge is swung around, bringing its long arm across the lock chamber and resting against a strong, masonry abutment on the further wall. From this superstructure, there is lowered into the lock chamber a series of strong frames, their lower end resting against a sill in the floor of the lock. After these frames are in position, a steel curtain is lowered on each of them, until the entire width of the lock is closed. The photograph shows three of these curtains in position on the right-hand side of the lock chamber.

Engineers will recognize the whole structure as generally similar to a well known type of movable dam used for slack-water navigation.

For the lighting of the locks, a substantial type of concrete lamp post has been designed, which has the special merit of using an inverted lamp and throwing the light downward. The long rows of these lamp posts on the lock walls will be a feature which will attract chief notice from travelers passing through the canal. The accompanying photograph shows the center approach wall to the upper locks of the Gatun flight, and there is also seen in the center of the picture, the lighthouse which will be a guide to mariners sailing down Gatun Lake.

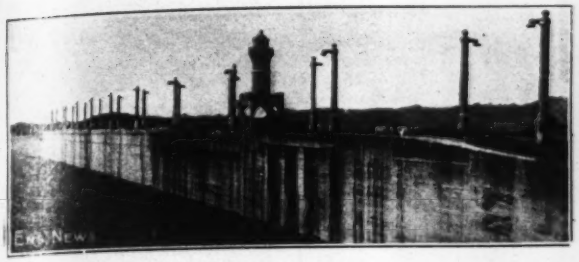
Another photograph in the series shows one of the last pieces of concrete work on the canal, the spillway near the Miraflores locks, which was completed Sept. 1. As those of our readers familiar with the canal line topography will recall, the summit level of the canal includes Gatun Lake and the whole length of the Culebra cut. At the southern end of the cut are the Pedro Miguel locks, by which a vessel is lowered about 25 ft. and enters a basin about a mile in length, extending to the flights of two locks at Miraflores, by which the remaining descent is effected to tide level on the Pacific side.

The Miraflores spillway discharges any surplus water from the basin between the Pedro Miguel and Miraflores locks. It consists of a weir of the usual ogee shape, surmounted by a series of substantial piers, between which are hung Stoney gates, by which the flow of the water may be regulated.

The *Canal Record* of Sept. 10 has the following concerning this work:

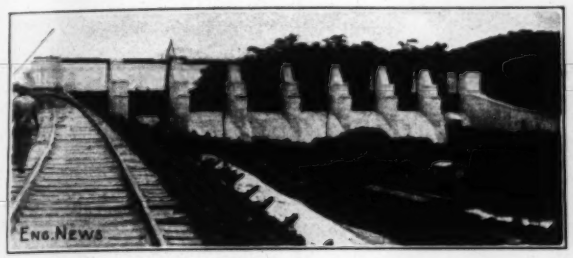
> It is believed that the completion of the Miraflores spillway dam on Sept. 1 constitutes a record for speed in difficult construction work on the Canal. In view of the fact that the waters of the Rio Grande River pass through the site and had to be diverted three times to facilitate the construction during the progress of the work, and also that prior to Mar. 1 of the present year the Central Division tracks from the Culebra Cut passed through the site, the excavation was greatly handicapped.
>
> The main dam is 432 ft. in length and has a bottom width of 91 to 105 ft., with the bottom on solid rock at elevation 25 ft. below mean sea level. The dam has two wing walls, each approximately 250 ft. long, and a core wall 134 ft. long joins the main dam with the lock walls.
>
> In order to make the gate joints watertight, it was necessary to set the steelwork for gates and roller-bearing tracks with accuracy, necessitating care in placing the concrete for

*The translation is Cockroach.

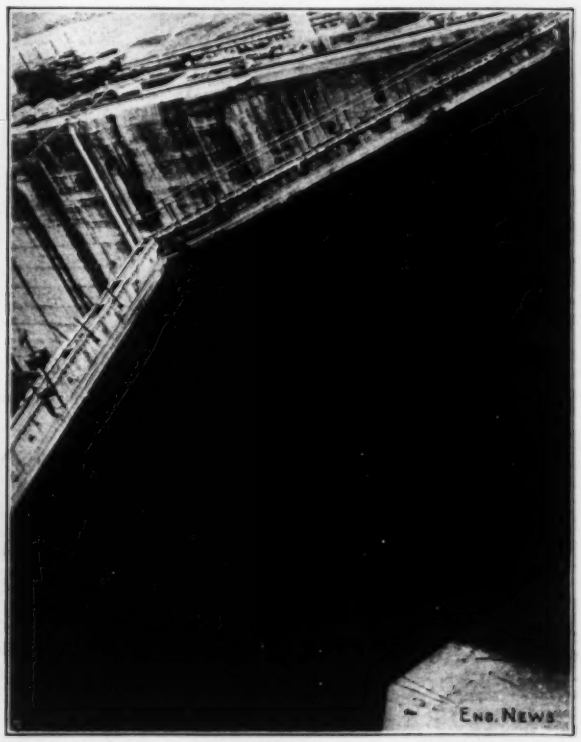


GUIDE WALL AT THE END OF THE UPPER GATUN LOCKS IN GATUN LAKE

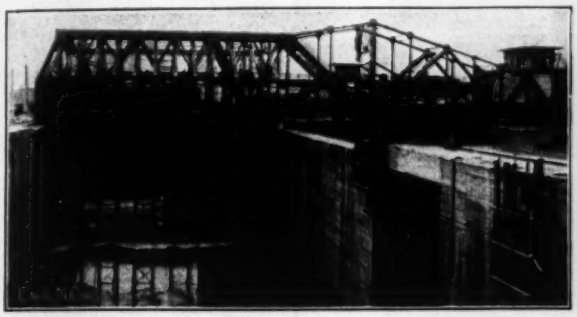
LOWER PORTION OF A PAIR OF LOCK GATES NEARING COMPLETION



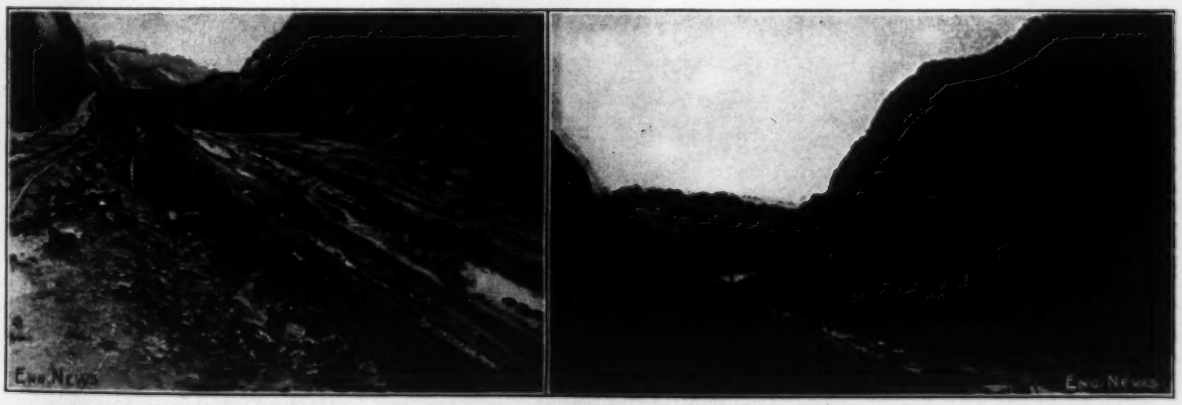
CONCRETE SPILLWAY NEAR MIRAFLORES LOCKS



A PAIR OF LOCK GATES COMPLETED AND CLOSED



ONE OF THE EMERGENCY DAMS AT THE PEDRO MIGUEL LOCK, SWUNG INTO POSITION



NEAR AND DISTANT VIEWS OF CUCARACHA SLIDE SOUTH OF GOLD HILL

(Village of Culebra on top of hill in the distance.)

[Photographs copyrighted by International News Service, 1913]

the piers lest the steelwork be deflected. There are eight Stoney gates 47 ft. long and 19 ft. deep. The gates weigh 40 tons each, and were handled from a trestle along the north face of the dam by two locomotive cranes, one at each end of the gate. The elevation of the crest of the dam is 38.67 ft., and the elevation of top of gate piers is 85.17 ft. above the mean sea level.

The total amount of excavation required was 135,000 cu.yd. The total amount of concrete laid is 73,482 cu.yd.

The Cost of Municipal Electric Lighting at Chicago*

By Ray Palmer†

On Jan. 24, 1898, the City Council of Chicago created, by an ordinance, the Department of Electricity. The report of the City Electrician for that year shows that a total of 1710 lamps were maintained at a cash cost of $68.52 each, for the year. Cash cost means all cost except the fixed charges; that is to say, except interest on the investment and depreciation of equipment.

From this time on, progress was made both as regards extensions to the system and decreased cost of maintenance. The annual report of the department for 1908 shows a total of 8602 lamps, maintained at a cash cost of $45.86 per lamp.

During 1908, the power generated by the Sanitary District of Chicago, at Lockport, was made use of to displace the steam equipment as a source of power for street lighting. Extensive alterations were made necessary by this change and the way was opened for increased extensions.

In October, 1910, a contract was negotiated whereby the Sanitary District should furnish and install 10,000 street arc lamps, or the equivalent in other type of lamps, in addition to those in service at that time (approximately 12,200). It was also to build the necessary substations, conduits and pole lines and supply the energy to operate the total number of lamps, approximately 22,200. The energy was to be furnished on the basis of $15 per hp.-yr. of 4000 lamp-hours, or approximately ½c. per kw.-hr.

In addition to this, the District undertook to operate the substations and plants at a cost to the city of $1 per arc lamp per year. The reason for this last undertaking was that the district desired the use of the station buildings and the transmission lines to furnish electrical power and light to private consumers during the time such buildings and lines were not required for city lighting purposes, and also to control all the power operating conditions.

This contract has been in force about two years and a total of 16,200 arc lights, or their equivalent in tungsten-filament incandescent lamps, are in service on the streets of the city. The remaining 6000 will be placed in service within a year, and the old direct-current arc lamps (2500 in number) will be displaced by the new flaming type. In 1913, a new contract was prepared, whereby 15,000 arc lamps could be added to those now under contract, and the obsolete 7-amp., alternating-current arcs could be replaced by the new flaming type, or the tungstens. This would give 38,000 flaming-arc lamps, or their equivalent in tungsten incandescent lamps. The proposed extension would cost $3,000,000 to $4,000,000. The Sanitary District reports that it is unable to accept this new contract until the U. S. Government grants an increased flow of water into the canal to generate the necessary current.

To equip one mile of street, using 23 flaming arcs and placing all wires underground, costs approximately $9000. If the wires were placed above ground on steel poles, the cost would be only about $4000. These costs include the substation and feeder distribution costs. On some of the older residence streets where the trees are well grown and act as an obstruction to the light from arc lamps, a system of underground cables, with tungsten lamps mounted in opalescent globes on the old gas posts, has been installed. This type of construction costs about $8000 per mile of street lighted, using 75 of the tungsten lamps, staggered and spaced about 150 ft. apart on each side of the street.

Flaming-arc lamps on underground circuits in 1912 cost $39.91 a year to maintain. Add to this an interest charge on the investment of $19.16 and a depreciation charge of $13.67, and the total yearly cost is $72.74 per lamp. While the lamp on aërial circuits costs as much to maintain, the interest and depreciation are lower and the total yearly cost is only $54.57.

The underground-circuit tungsten lighting is the most expensive form of street lighting we have, except gasoline lighting, which is $31.25 per year. The cost per unit is only $13.36 for maintenance of the tungsten lamps, but the interest and depreciation costs bring this amount up to a total of $24.27 per lamp yearly. As there are 75 lamps to the mile of street, this means an annual cost of $1673 for flaming arcs on underground circuits, $1255 for flaming arcs on aërial circuits, and $5343 for gasoline lamps.

In July, 1912, an ordinance was passed to protect the underground cables and other metallic structures from electrolysis, and on Jan. 27, 1913, another ordinance was passed standardizing all arc-lighting and commercial-lighting poles within the city. The various railways will be forced to install and maintain lights in 275 of the street subways, where such action is required under the track-elevation ordinances. The city will install and maintain lights in all other subways (about 350). After extensive engineering investigation, a standard of one 16-cp. lamp for each 400 sq.ft. of inclosed subway area, was decided upon. The railways have been trying to get this reduced to one such lamp for each 800 sq.ft., but the department has insisted upon the necessity and fitness of the lighting selected.

Electric Lighting Work of the Sanitary District of Chicago

The hydro-electric development of the Sanitary District was made possible by extending the main channel of the drainage canal below Lockport and utilizing the resultant head. The plant was put in service Dec. 28, 1907, with a connected load of 165 hp. in the town of Cicero. It now supplies several places around Chicago, and in January, 1913, it was estimated that the District was furnishing current at a net saving to the municipalities and parks in annual cash costs of from $450,000 to $500,000.

The arc-lighting load is supplied on a lighting schedule varying from 8 to 14 hours per night, and at an average of about 0.5c. per kw.-hr.

The installation at the power house is of seven equal units, totaling 28,000 kw. The development can take care of a 24,000-kw. peak load and a continuous load of about 20,000 kw. In addition the Sanitary District has 3500 kw. in steam plants, which can be used as reserve and for peak-load periods. The power is transmitted a distance of 30 miles at 44,000 volts to the main distributing and transformer station at 31st St. and Western Ave. From this point, it is distributed at 12,000 volts to the 30 stations in Chicago and the suburbs.

In the 12,000-volt lines feeding these various stations there are about 80 miles of cable and about 85 miles of overhead lines. Practically all of the lines feeding the lighting stations in Chicago are underground, the aërial lines being used to supply the stations at outlying suburbs. The stations are so inter-connected that there is little danger of main-feeder trouble throwing portions of the city in darkness.

The electrical department of the Sanitary District deserves credit for a number of important changes in the street-lighting system of Chicago, as it advocated these changes, has done much of the necessary engineering and experimental work, and has coöperated with the city to make these changes successful. The most important of these changes was the adoption of the long-burning series alternating-current flaming-arc lamp. When this lamp was first considered there was no lamp of this type in service or on the market. It was only after much experimental work had been done that a lamp of this type was produced which would operate satisfactorily.

Another important feature is the adoption of the series tungsten system for residential districts, using the old gas-lamp posts and providing them with a standard post head and large spherical globe. Underground circuit construction is used, and the system is very attractive in appearance and has given entire satisfaction.

The Extensive Dredging Operations required to keep to a proper depth the approach channels to the Port of Liverpool, are well shown in the recent annual report of the Engineer-in-Chief to the Mersey Docks and Harbor Board. This report shows that during the year ending July 1, 1913, 16,496,850 tons of material were removed from the bar, channel and shoals outside the harbor. One dredge, the "Leviathan," was responsible for 11,000,000 tons. Since dredging was begun in 1890, the quantity of sand removed from the bar is nearly 52,500,000 tons; from the shoals in the Queens and Crosby channel, over 151,500,000 tons, the grand total reaching 204,000,000 tons.

*Abstract of a paper read before the City Club of Chicago.
†City Electrician, Chicago.

*By A. B. Gates, Testing Engineer, Sanitary District of Chicago. Abstract of a paper before the City Club of Chicago.

EDITORIALS

An International Investigation of the Pollution of Boundary Waters between the United States and Canada

A refreshing spirit of common sense runs through the preliminary report on the "Pollution of Boundary Waters" (United States and Canada) published last month by the International Joint Commission.

In the first place, we note that the governments of the United States and Great Britain have agreed to confine the inquiry "to cases of pollution of boundary waters on one side of the boundary which extend to and affect the boundary waters upon the other side."

Secondly, we are particularly pleased to see that the committee to which the full commission has referred the pollution problem (Frank S. Streeter for the United States and Henry A. Powell for Canada) has concluded that in the case of the waters which have thus far been given the most study (the Niagara River) purification of the water-supplies drawn from the river is to be insisted upon, regardless of what sewage treatment may be required. Some sewage treatment will be necessary, but the possible extremes are now as far apart as (1) "a very slight and inexpensive treatment" and (2) "complete sterilization" of the sewage—with an evident strong leaning toward (1), but this is wholly our own inference.

Another indication of the common-sense spirit of this committee is its indorsement of findings 10 and 11 of the report of the Committee on Standards of Purity (Geo. C. Whipple, Chairman), submitted on Oct. 22, 1912, to the National Association for Preventing the Pollution of Rivers and Waterways (ENG. NEWS, Oct. 31, 1912). These findings embodied a rational basis for the regulation of water pollution in accordance with local conditions, taking into account the burden which can reasonably be placed upon water-purification plants.

While printed merely as a part of evidence before the committee, note may be made of the frank comment of Col. W. L. Fisk, Corps of Engineers, U. S. A., on the proposal of the Erie & Ontario Sanitary Canal Co. to solve the pollution problem of Buffalo and adjacent cities by the construction of a sewage, navigation and power canal between the two lakes, which has been vigorously promoted during the past five years. After stating (Nov. 16, 1908) that the petition as then before the War Department "deals in large and glittering generalities only," Col. Fisk says further that the project "under a thin mantle of public health and other things" appears to be a 200,000-hp. power scheme, involving the diversion of 6000 cu.ft. per sec. of water from Lake Erie in a way that would probably so affect "all the extensive Buffalo harbor improvements" as to render the approval of the War Department unwise.

The canal project just mentioned, as well as other facts bearing upon the Niagara River problem, will be considered at a hearing at Buffalo during the present month.

It may be added that laboratory and other investigations to delimit the waters to be acted upon by the International Joint Commission are being conducted under the direction of Dr. Allan J. McLaughlin, of the United States Public Health Service, as chief sanitary expert, aided by Dr. J. W. S. McCullough, chief health officer of the Province of Ontario, and Dr. John Amyot, professor of hygiene, University of Ontario. The state departments of health of New York and Michigan and the provincial health department of Ontario, are coöperating with the committee, which also testifies to the friendly spirit shown by Buffalo and other cities involved in the Niagara River problem.

It has been determined that the "Detroit River, including connecting waterways between Lake Huron and Lake Erie, furnishes a difficult problem—possibly greater than the Niagara conditions." It had also been concluded, last month, that the committee must investigate the St. Mary's River, the St. Lawrence River from Lake Ontario to the boundary and a part of the St. John River. Consideration is also being given to pollution by Lake vessels.

From the foregoing comment and outline it will be agreed, we think, that the Committee on Pollution of Boundary Waters has entered upon an important work in a commendable spirit and with good promise of obtaining notable results. The report just issued, it should be understood, is merely preliminary. It was printed at Washington, D. C., for the International Joint Commission on the Boundary Waters between the United States and Canada.

A Good Beginning in Water-Waste Prevention at Philadelphia

The willingness of Philadelphians to accept any sort of water so long as it is wet rather than submit to waste-prevention measures was briefly commented on in our issue of Sept. 18, 1913. The opposition seems to have reached its height in 1904 when the city councils even went so far as to pass an ordinance prohibiting the installation of meters, so great was the fear that the consent of an occasional consumer to take water through meters would prove an opening wedge to their general use. Later on, this ordinance was repealed, and last year, with a reform mayor and his executive staff, a water-waste exhibition was held at the city hall. During the past year, also, house-to-house inspection of water services and pitometer surveys have been inaugurated in West Philadelphia, with the marked reduction in water consumption and waste reported elsewhere in this issue by Mr. Ely.

In a large city which had a per capita water consumption ranging from 202 to 239 gal. a day from 1898 to 1911, it was certainly high time to begin a progressive

campaign against waste. The work done in 1912, although confined to a relatively small part of the city, was followed by an average per capita consumption of 195 gal. in 1912. It is only fair to add that for the past half-dozen years the per capita consumption has been kept down near the 200 mark, but whether through the activities of the Water Bureau and the coöperation of the people or the fact that the population was pressing too hard on the capacity of pumps and filters we cannot say.

One feature of the directions to waste inspectors would strike water-works managers in many other cities, and particularly in Great Britain, with surprise; leaks of less than ¼-in. stream are to be passed by with no further notice than to call them to the attention of the householder, as "it is of much more importance to spend the time in finding large leaks." No wonder Philadelphians object strenuously to water meters when a leak flowing a ¼-in. stream is of relatively small importance!

The water-waste survey described by Mr. Ely is commendable in plan and results, so far as it goes, and it is to be hoped that it will be rapidly extended to cover the whole city. It is noteworthy, however, that the cost per building inspected in the first half of 1913 was a trifle over 7c. per building. Now how long will the effect of an inspection last? In many instances about as long as it takes the inspector to get out of the house.

To be continuously effective, would require an inspector on duty in each house, and that, at Philadelphia wages, would cost $2.50 per day per house. As we have said more than once, the only water-waste inspector that is always on the job is the water meter.

The First Full-Sized Locomotive Propelled by Oil Engines

We publish elsewhere in this issue a description and detailed drawings of the first railway locomotive operated by a Diesel crude-oil engine, built by the famous European firm of Sulzer Bros. Since it was announced two years or more ago that this firm in coöperation with Dr. Diesel had undertaken the application of the Diesel oil-engine to locomotive propulsion, there has been great curiosity as to the manner in which the difficult problems of the design would be worked out and as to the success of the venture.

We cannot speak too highly of the courage exhibited by the engineers who undertook this enormously difficult feat in mechanical design. Any engineer who knows what are the requirements that a railway locomotive must fulfill to meet the conditions of practical operation and who is familiar also with the design and construction of the Diesel oil engine, will understand at once that the first requisite in undertaking this task was a very rare quality of courage. We are safe in saying that there are very few machinery-building concerns in Europe, and we know of none in the United States, who could have brought together the requisite skill and experience in design and construction to have carried this task through to success and built a locomotive which would be mechanically operative.

Little is said, in the description furnished us by the builders, as to the results obtained with the locomotive in practical operation. From the detailed description given there is no apparent reason why the machine should not be an operative success; that is to say, why it should not draw a train over the road and be under the necessary control in executing the various operations of starting, accelerating, reversing, etc.

But it is one thing to build a machine which will be an operative success mechanically, and it is quite another thing to build a machine which can attain commercial success. It must be frankly said that under the conditions of American railway operation, at least, this Diesel locomotive would be practically impossible of use. Even in Germany, where it is possible to obtain at a moderate rate of wages highly skilled mechanics for locomotive operation and maintenance, it would seem to us extremely doubtful for many reasons whether this oil-engine driven locomotive can compete with the old-time steam locomotive.

To sum up the situation in a word, there is too much machinery to the Sulzer-Diesel locomotive. There is such a number of complicated and intricate parts to be oiled, maintained, inspected, adjusted and taken care of that the three features of ruggedness, reliability and power to withstand abuse—highly necessary features in a railway locomotive—appear to be certainly lacking.

This is not merely an impression gained by study of the principles on which the design is based and of the detail drawings of the machine, but coincides, we happen to know, with the opinion of one of the ablest railway mechanical engineers in the United States who has examined the locomotive itself.

It is unfortunate that this is the case, for there is undoubtedly an opportunity for large commercial success if the oil engine can be adapted to locomotive service. The opportunity for commercial success, however, does not lie in the direction which the designers of this first Diesel locomotive have followed. They set out to build a fast passenger locomotive of 1000 hp.; but for regular road service, either passenger or freight, the present-day steam locomotive is so successful from every point of view and operates at such a small cost that we see no possibility of its replacement by any type of internal-combustion machinery.

It is, we believe, for application to locomotives of comparatively small power that the internal-combustion engine has its great opportunity. Indeed, many small locomotives driven by gasoline engines are already in service and the number is rapidly increasing. A 200-hp. machine with a weight of 43,000 lb. on the driving wheels has just been built for the Minneapolis & Northern Ry. A limit is set to this development, however, not only by the mechanical problems in connection with the driving of a machine of large power through gearing, but by the heavy cost of gasoline when any large power unit is involved.

Altering the design of such machines to burn kerosene or some heavier and cheaper oil, and if possible to increase their fuel economy at the same time, on lines similar to those followed in the Diesel engine, would seem to be the best means of extending the range of commercial success for this type of machine to larger powers.

One of the greatest opportunities for a successful internal-combustion locomotive appears to be in connection with switching service in city freight and passenger yards, especially where anti-smoke legislation and compulsory electric operation are impending dangers as is

the case at Boston and Chicago and to a lesser extent at a dozen other cities. A switching locomotive works usually at such slow speeds that its actual power developed is comparatively small. What is wanted is a machine of larger power than the small gasoline machines, but of much smaller power than the full-sized road locomotives for freight and passenger service, which will have at least as much flexibility and reliability in operation as the present-day automobile engines, and which will avoid the dangers and expense inseparable from the use of gasoline by using some cheaper and less volatile fuel.

The successful development of such a machine, either here or abroad, would save the railways many millions of outlay on compulsory electrification, which is now threatened in many quarters.

A Comparison of Railway Casualties in Great Britain and in the United States

It has long been well known to those familiar with railway practice both in this country and abroad, that the rate of casualty in railway travel is far higher in the United States than it is in Great Britain. It is many years, however, since comparative statistics of accidents in the two countries have been presented in the columns of ENGINEERING NEWS.

This matter has been brought to the fore recently by public discussion in connection with the recent disastrous collision on the New York, New Haven & Hartford R.R. It happened that almost simultaneously a bad collision, in which a number of lives were lost, occurred on the Midland R.R. in England. This occurrence was taken advantage of by various journals to suggest that after all American railways were perhaps no worse as regards accidents than those of other countries. The New York *Times* in particular, in an editorial article, published statistics by which it claimed to show that the average rate of casualty in railway travel in the United States was not greatly different after all from the casualty rate in Europe.

What the source of these statistics may be, we do not know. It would be a huge task indeed, to compile the railway-accident statistics of all the different countries of Europe (even if such accurate statistics are obtainable from all of them, which is very doubtful), in order to obtain a total average, fairly comparable with that shown by the statistics collected by the Interstate Commerce Commission in the United States. It is easily possible, however, to make a fair and very accurate comparison between the accident statistics of the railways of Great Britain and Ireland and those of the United States.

In both countries, all the operations of steam railways are under government supervision; in Great Britain by the Board of Trade, an important government department, and in the United States by the Interstate Commerce Commission. In the United States, statistics of traffic and accidents have been collected ever since the establishment of the Interstate Commerce Commission, 26 years ago. The work of the British Board of Trade, in a similar field, has continued for a very much longer period.

To compare the safety of travel as affected by differing railway practice in the two countries, it is most instructive and accurate, we believe, to take the casualties to passengers in train accidents alone. While a far greater number of passengers are killed in getting on and off trains than in all the train accidents combined, the former class of accidents are due, in most cases, to the carelessness of the passenger himself. In order to compare the relative safety of railroad operation in the two countries, we should consider only accidents for which the passenger is in no way responsible.

In the year 1910, the Interstate Commerce Commission statistics showed a total of 198 passengers killed in train accidents on the steam railways of the United States. During that year, the total number of passengers carried was 971,683,199. It, therefore, appears that in that year one passenger was killed for each 4,900,000 passengers carried.

Turning now to Great Britain, the last available annual official report of the British Board of Trade states that the average rate of casualty to railway passengers in train accidents during the ten-year period ending in 1909, on all the railways of Great Britain and Ireland, was one passenger killed for every 72,000,000 carried, or a rate of casualty less than one-fourteenth as great as that in the United States.

It is objected, however, that a comparison by the number of passengers carried is not fair to the United States, since the average length of a railway journey is much greater here than in Great Britain. The length of the average passenger journey in the United States in 1910 was 33⅓ miles. Statistics of British railways are not so kept as to show the traffic statistics in miles. It should be taken into consideration, however, that the British accident statistics above quoted do not include journeys by holders of season tickets in the total of passenger journeys; and in this class of travel a very large proportion of the short-distance traffic occurs. If we assume that the average length of a passenger journey in Great Britain is only a third of that in the United States, or 11 miles (which is almost certainly far too low when season-ticket holders are excluded) we still have an average casualty rate in railway passenger travel in the United States nearly five times as great as that on the railways of Great Britain.

In considering these figures, however, it should be understood clearly just what they show and what they do not show. It does not follow at all from these figures, for example, that whenever a traveler takes a railway journey in the United States, he is in five times as great danger of death as he would be in a British railway carriage. There is a considerable mileage of railways in the United States that is now so well equipped and so well managed that the casualty rate to passengers traveling upon them probably approaches the low figure reached on British railways. The average rate of railway casualties in the United States is kept high by the defective appliances and poor discipline on many railways which suffer from poor management in one department or another. It is fair to say also that the same situation exists to a certain extent in Great Britain, where the average for the whole country is held down by the records of the roads with poorer management.

The excuse is often made, when a railway collision occurs in the United States, that the road at the time was carrying a very heavy traffic. It appears to be

thought by the general public, and possibly by some railway managers, that the necessity of handling a great number of trains on a line is some sort of an excuse for the occurrence of occasional collisions. We need not go abroad to see the fallacy of any such idea, in view of the almost absolute freedom from collision with which such roads of extraordinarily dense traffic as the New York Rapid Transit system is operated, or the Rapid Transit lines in Boston. The same thing is shown very forcibly, however, by these British statistics. On the 20,000 miles, or thereabouts of steam railways in Great Britain and Ireland, more passengers are carried per annum than on all the 200,000 miles of railway in the United States. These statistics mean, of course, that the density of traffic on English railways, is very far greater than in this country. Not only this, but foggy weather, in which it is difficult to observe signals, is very much more prevalent in Great Britain than in the United States. Were these conditions reversed, doubtless some would try to find therein an excuse for the far too frequent railway collisions in this country.

As has been many times shown in these columns, there can be little doubt that the remarkable safety with which British railways are operated, especially with respect to freedom from collision, is due to the universal use of the absolute block system. For more than a generation, practically all the railway lines of Great Britain have been operated on the absolute block system. Its use was, in fact, made compulsory, by the Board of Trade, nearly thirty years ago. As far back as 1881 five-sixths of the double-track railway mileage in Great Britain was equipped with absolute block signals. For many years the Board of Trade published in each annual report, statistics of interlocking and block-signal equipment on all British railways. In the year 1894, the last year for which statistics are available, 99.6% of the total mileage of double-track railway in Great Britain was worked on the absolute-block system. Of 8550 miles of single-track railway, 7296 miles were worked on the absolute-block system and 412 on the train-staff system. On 770 miles remaining, the system of operation was such that only one locomotive under steam (or two coupled) was allowed on the road at one time, a system of operation under which, obviously, collisions would be impossible.

It is said, we are aware, that even where the block system is in use on American railways, enginemen do not observe it with the same unvarying fidelity as British locomotive runners. It is usual to ascribe this to a difference in the discipline here and abroad. There is, however, yet another reason. The British locomotive runner has been accustomed practically all his life to operating under the block system and nothing else. Day after day and year after year, every mile that he travels on the railway he is guided by the signal indications. He knows that the block signals and the block signals alone, protect his life and the lives of his fellow employees and the passengers under his care.

In contrast with this, on a large percentage of American railways, the engine runner in the cab has run under the block system only a few years—perhaps only a few months. Sometimes, there are two or three different kinds of block signals in the course of a run. Often part of his run is under block signals and part is not. Even where the block system is in use, his superior officers emphasize their lack of confidence in it by continuing the old rules for back flagging. These are among the contributing causes which cause a percentage of error in signal observance on American railways that is doubtless far higher than prevails in Europe.

It has seemed to us worth while to set down these facts, because their lesson to American railways and to the American public is so important that they ought to be widely known. In our issue of Sept. 11, we took occasion to emphasize the lesson which the disastrous collision at North Haven ought to teach, with respect to the improvement of American block-signaling practice. It is greatly to be regretted that some prominent railway officials and some technical journals have, either through ignorance or intention, attempted to cloud the facts in the case, and divert public attention from the really vital features of the disaster. It is for this reason especially that we have deemed it worth while to set down above what the official statistics show with respect to the relative casualties in railway travel here and in Great Britain, and in connection with this, the long period in which the absolute-block system for the prevention of collisions has been in practically universal use there.

LETTERS TO THE EDITOR

The Unfairness of Organized Labor

Sir—I have read ENGINEERING NEWS and other engineering periodicals for the past ten years, with the object of broadening my knowledge of engineering subjects and problems generally; but there is *one* most important problem which is developing to astounding proportions, which has been conspicuously absent from your editorials and contributions.

Every practical engineer who has been compelled to contribute his time and money, in the adjustment of controversies arising from the abused privileges of the labor unions, will readily recognize in this subject one which is of more vital importance at this time, to the engineering profession at large, than the solution of analytical equations.

The duties of a successful engineer, during the past eight or ten years, have undergone quite an evolution. We now find at the head of various business institutions, engineers who have proved susceptible to practical influences, resulting in a displacement of theoretical ideas by a thorough understanding of how to cope with the many problems incident to efficient management.

The engineer of today who occupies an executive po-

sition of importance, in a successful construction company for example, must possess marked initiative, be an organizer, know how to economically design and construct buildings, bridges, etc., how to obtain a loan when necessary, must have a knowledge of the laws of contracts and the best way to prevent trouble by avoiding court proceedings, a clear understanding of accounts, the difference between a debit and a credit, and a general knowledge of all the fundamental business principles essential to the success of any management. All these requirements are the result of intuitive fitness, experience and close application to duty; but the solution of the labor question which is today assuming such proportions as to cause national alarm, can only be reached by coöperation on the part of builders, engineers and capital, with some concerted action directed to influence politicians throughout the country to legislate against the present abuses.

To illustrate: about two weeks ago information was received by wire, from the superintendent of a large building in the East, that all the trades had decided to suspend operations, pending settlement of a controversy which had arisen within the ranks of the several trades, to determine which was entitled to install the cork insulation required in the building. The contractor and owner did nothing to contribute to this difficulty, yet the time and money lost had to be accepted with good grace, as a matter of course.

Work on a large office building now nearing completion in the Southwest was indefinitely suspended on account of a question that arose between the trades as to who should install the metal frames and sash. The carpenters claimed the work, so did the sheet-metal workers, and the local labor organizations gallantly sympathized with both and quit their jobs until a settlement could be reached. No consideration was given the contractor or owner. Advantage was taken of this situation in the form of a demand from the local head of the sheet-metal workers, that unless some pressure was brought to bear to force the manufacturer of the metal windows to unionize its shops, this work would not be installed. The unions are usually successful in forcing any demand, just or unjust, without any pretense of arbitration or any due recognition of the rights of contractors or owners.

During the past Republican as well as the present Democratic administration, we find the Attorney General's office diligently making investigations into the affairs of the various corporations, to discover any suspicion of monopoly, to warrant litigation and subsequent dissolution. Our professional politicians and others, have viewed the labor trust at long range, not desiring to jeopardize their jobs by delving into the affairs of this gigantic monopoly, which controls such a large percentage of the vote of this country.

It occurred to the writer that the engineering profession would be vitally interested in this subject, if through your columns the important phases of the question could be discussed, with the ultimate object of influencing some effective legislation to prevent a continuance of the present abuses.

W. J. KNIGHT.

724 Wainwright Bldg., St. Louis, Mo.,
Sept. 16, 1913.

[The questions raised by our correspondent's letter are of the greatest importance to engineers holding positions of large executive responsibility, and to the public; but like numerous other questions in connection with government, politics, economics and sociology, they can only claim a secondary place in the columns of ENGINEERING NEWS, which must devote its chief space to the technical problems with which the engineer has to deal.—ED.]

State Regulation of Utilities Under Municipal Ownership

Sir—In your editorial of Sept. 4, you speak of Wisconsin as the only state which imposes the same burden on all utilities alike, whether municipally or privately owned. I venture to call to your attention the fact that the Massachusetts law has for nearly a generation intended to, and substantially does, control the municipally owned as well as the privately owned gas and electric plants.

That Wisconsin should have taken advantage of Massachusetts' experience to pass, after many years, a still better law, is to her credit. But the greater credit should go to the state, which in this, as in practically all the modern ideas of commission regulation, publicity of accounts, indeterminate franchise, etc., has led the way.

R. S. H.

Boston, Mass., Sept. 23, 1913.

[The Massachusetts statutes provide separately and specially for the regulation of certain municipal utilities. However, all the desired ends seem to be sought therein as our correspondent contends.—ED.]

Railway Curve Formulas

Sir—On p. 859a of Kent's "Mechanical Engineers' Pocket Book" I find the following formulas for curves (Baldwin Locomotive Works):

1. Approximate formula for radius: $R = 0.7646\ W \div 2\ P$. Here R = radius of minimum curve in feet; P = play of driving wheels in decimals of 1 ft.; W = rigid wheelbase in feet.

2. Approximate formula for swing: $(W\ T) \div (2\ R) = S$. It is with formula (2) that I purpose dealing. To my mind, the extra width of gage required in order that a locomotive (4-4-0 class) may pass around any curve without binding is just the ordinate to the outer rail measured from the flange of the forward driving wheel at the point of contact.

KENNETH MCINTOSH.

St. Peters, Richmond Co., Nova Scotia.
Aug. 20, 1913.

[We omit our correspondent's discussion of the formula, for the reason that this formula is incorrectly given in Kent's "Pocket Book," as was pointed out in a discussion of this subject in our issue of May 11, 1911. Further, the formula for swing of truck does not relate to width of gage.

The Baldwin Locomotive Works informs us that the correct formula is as follows: $(W\ T) \div (2\ S) = R$. In this, W = distance from center pin of truck to rear of rigid wheelbase; T = distance from center pin of truck to front of rigid wheelbase; S = half the total

swing of the truck; R = radius of sharpest curve which can be passed. This gives the relation between the truck swing, wheelbase and curve radius. It is approximate only, but sufficiently accurate for all practical purposes. For cases where extreme accuracy is required, a formula given by the Baldwin Locomotive Works is as follows, in which A = the length of rigid wheelbase, and B = distance from center of front driving axle to center pin of truck, when the engine is on tangent:

More About Venturi Meter Coefficients

Sir—I have read Mr. Hazen's article on "Venturi Meter Coefficients" in your issue of July 31, 1913, and do not believe that the throat coefficient of the meter is a constant. In fact, the meter nozzle, as well as the Venturi meter, does not have a constant coefficient of discharge. I think there is a good reason for this. A constant coefficient, which with Venturi meters and meter nozzles means a very high one or practically the theoretical discharge of the orifice due the velocity, must require a very perfect shaping of the channel of approach and discharge to get such a result; and this result is only possible when the conditions exactly fit some particular velocity, usually near the middle limits of the meter.

In connection with my course on water-power engineering at Harvard University, I have had occasion to make volumetric measurements of Venturi meters, meter nozzles, small weirs, etc., up to a capacity of 2000 gal. per min. in a lock 120 ft. long, 12 ft. wide and 12 ft. deep, which we know to be absolutely tight. A number of ratings of a 10-in. Venturi meter so far, without exception, have shown that the values progress pretty regularly from about 97% at small discharges to 100% with large; while the meter nozzles follow about the same tendency, but nozzles of one size approach a coefficient of 1.00 more nearly than others.

We shall make a number of further ratings of Venturi meters for the Builders Iron Foundry, which will give a much larger number than before of actual experimental values; and which will either confirm the measurements already made by us or bring out some new conditions which we have not yet found.

ARTHUR T. SAFFORD.

Lowell, Mass., Aug. 7, 1913.

[On submitting proof of the foregoing letter to Mr. Hazen we received the following reply.—ED.]

Sir—I am glad to know that Professor Safford is to make further ratings of Venturi meters, which will add much needed information.

In regard to the irregularity of the nozzles affecting the constancy of the coefficient, it may be suggested that as the resistance due to any irregularities that there may be increases as the square, or nearly as the square, of the velocity, and as the head increases in the same ratio, the percentage effect of such irregularities will presumably be the same, or nearly the same, for all velocities; and while such resistance would tend to lower the coefficient, there is no apparent reason why it would lower it more at low velocities than at high ones.

I am particularly interested to see that Professor Safford's experiments indicate that the coefficient increases with velocity, thus confirming Mr. Ledoux's experiments. As further experiments are to be made for the Builders Iron Foundry, it may not be amiss to point out that the instruments made by the Builders Iron Foundry up to the present time have been based upon the opposite proposition, namely, that the coefficient of discharge decreases as the velocity increases.

ALLEN HAZEN.

Forty-Second Street Building, New York City,
Aug. 15, 1913.

The Problem of Turbine Capacity for Water-Power Development

Sir—The problem of finding the proper turbine capacity to be installed at a water-power site, discussed by Mr. Clemens Herschel, in ENGINEERING NEWS, Sept. 4, is one of vital importance to engineers engaged in the design of water-power plants.

Mr. Herschel has taken the average flow of the stream for six months as the basis for determining the proper turbine capacity to be installed. This assumption has evidently been made arbitrarily and does not consider any of the local conditions governing each individual vide for future available power.

The amount of water power to be developed at any site is largely determined by certain commercial and economic conditions, such as (1) the amount of the present and prospective power requirements within the territory to be served; (2) the character of the annual load curve; (3) the annual cost of steam power; (4) the unit cost of water power to be developed. No water-power development, either constructed by private interests or by the state and national governments, is justified unless it can be made a commercial success.

The question of how much surplus capacity should be installed, or allowed for, to take care of the future power requirements, depends largely upon the prospects of future additional load as well as the additional annual cost required after the completion of the plant, to provide for future available power.

The character of the annual load curve is also of importance. Practically all rivers capable of water-power development are subject to the wide fluctuations in the stream discharge. Where power can be economically sold for a portion of the year, then the development in excess of the minimum discharge is justifiable. This so called secondary power, of course, is sold at a considerably lower rate to industries owning their own steam plants, and likewise to industries such as pulp and paper mills that can economically use a large amount of power, for six or eight months of the year. It is evident that no water-power development is justified unless the power can be generated at less than the cost of steam power from a plant of similar capacity. While it is true that nearly every water-power plant can be greatly benefited by the installation of an auxiliary steam plant, thereby permitting the sale of a larger amount of guaranteed primary power, nevertheless, in every such water-power development, there is a limit to the size of such auxiliary steam plant, beyond which it is not economical to go.

There are a number of notable failures of water-power developments, due primarily to over-development. It must be borne in mind that the investment charges on the auxiliary steam plant, as well as the cost of auxiliary

steam power must be charged against the cost of the water power. This requires that the unit cost of the water power developed must be within a reasonable limit.

The foregoing observations are made in order to apply them briefly to the proposed development of the water power at Great Falls, near Washington, D. C., referred to in Mr. Herschel's article.

The writer desires to show, that a proposed development of a 100,000-hp. plant at this site is not justified by any of the conditions mentioned above. It is unfortunate that the necessarily limited length of this letter will not permit a description of this proposed water power, which has many interesting features. Last year, the writer had occasion to make an investigation of the water-power possibilities at Great Falls, for a company owning certain water rights at this point, and a careful study of the proper turbine capacity was made. The conclusion reached was that the proper draft of water for the turbines would be 1870 sec.-ft., which would have been available for 79.09% of the time from 1895 to 1910 inclusive. The accompanying table shows the deficiency in steam discharge at Great Falls below 1870 sec.-ft. It is to be noted that Mr. Herschel plans an ultimate development to utilize 6800 sec.-ft.

DISCHARGE OF POTOMAC RIVER AT GREAT FALLS, MD.
(1895 TO 1910 INCLUSIVE)

Flow, Sec.Ft.	Percentage of Total time	Total Days Deficiency in any year	Total Days Deficiency
1050	99.88	6	7
1170	99.3	23	41
1400	96.67	58	213
1630	89.75	86	600
1870 and above	79.09	107	1222

The federal government proposes to construct a power development with a present initial capacity of 20,000 hp. delivered and an ultimate capacity of 100,000 hp. delivered, utilizing an average head of 111 ft. The present normal load requirements by the city and national governments amount to 9300 hp., with a peak load of 15,000 hp., during a period of four hours. Mr. Herschel estimates, that in 1937, the peak load will be 47,000 hp., but no estimate is made as to the time the ultimate capacity of 100,000 hp. will be required.

The wisdom of planning a water-power development on such a large scale to meet the probable demands of power in the distant future is certainly a matter of doubtful expediency, especially in view of the great changes experienced in hydro-electric power-plant practice in the past 15 years.

The unit cost of development per horsepower, delivered according to Mr. Herschel's estimates is as follows:

For a development of 20,000 hp., $392.50 per hp.; 47,000 hp., $180 per hp.; 100,000 hp., $91 per hp.

Mr. Herschel estimates the cost per kilowatt-hour on the power-house switchboard would be 6.9 mills when plant is started and 2.5 mills when the power is fully developed. According to these figures, the writer estimates that the cost of power per kilowatt-hour in 1937 with an installation of 47,000 hp. will be 3.6 mills. This does not include the cost of necessary auxiliary steam power.

At the present time, the United States Capitol isolated power plant, with an approximate capacity of 10,000 hp., will serve the purposes of a steam auxiliary. In 1937, an auxiliary steam power plant of 32,500 hp. capacity will be required and when the ultimate capacity of water-power plant is reached, a steam auxiliary plant of 66,700 hp. will be required.

A good grade of steam coal costs $3 per ton here in Washington, and power is now being produced at a cost of approximately 7.5 mills per kilowatt-hour. With the proper charge for auxiliary steam power, for an initial development of 20,000 hp., there would be no apparent saving in cost of power, by means of this water power. When the water-power installation has reached 47,000 hp., the total estimated output of the combined plant would be 181,000,000 kw.-hr. The steam plant would be operated for 111 days in the average year and the total yearly output would be, approximately, 30,000,000 kw.-hr. The cost per kilowatt-hour for water power for a total yearly output of 151,000,000, would be 4.2 mills and the cost of the steam power, 7.5 mills. The total cost of all power would be 4.7 mills. It should be noted that in estimating the yearly cost of power, Mr. Herschel has taken interest charges on power-plant investment at 3%, and depreciation on electrical and hydraulic machinery at 3%. These low rates materially reduce the estimate of power cost.

The writer believes that, with the prospect after 25 years operation of a maximum saving of only 2.8 mills per kilowatt-hour over the present cost of steam power, and without considering what may take place, during this period to reduce to cost of producing steam power in 1937, the proposed water-power plant seems to be a commercially unsound project.

We have heard many arguments in recent years in favor of government ownership of water power, but if such projects are to be successful, they must be constructed with due regard to economic and commercial conditions.

FRANCIS R. WELLER.

Hibbs Bldg., Washington, D. C., Sept. 13, 1913.

A Decision on Subway Construction Damages—Sewer diversion done in connection with the construction of the Paris Métropolitain rapid-transit subway led the owner of a store on the street in which the work was done to make a claim for damages against the City of Paris. The claim was rejected by the Prefect of the Department of the Seine, and on appeal the rejection was upheld by the Government Council. The grounds for the decision were that the construction work had caused no physical injury to the buildings and had not interfered with the accessibility of the buildings, in view of the fact that access by wagon as well as by foot had not been interrupted at any time during the work. The claimant had not proven that the presence of the construction work diminished his business. Under these circumstances, the Council considered that no damage had been shown. [Annales des Ponts et Chaussées, July, 1913, p. 573.]

Tank Locomotives of the 2 : 12 : 2 Class have been built for the Java State Railways, and are said to be more satisfactory than Mallet duplex engines of the 2 : 6 : 6 : 0 class, being less liable to slip on account of the large number of wheels coupled into one group. The engines can operate on curves of 460- and 500-ft. radius, the track gage (3 ft. 6 in.) being widened a little over $\frac{5}{8}$ in. for the former and $\frac{3}{4}$ in. for the latter. The first of these engines was described and illustrated in our issue of Sept. 19, 1912, and an article in the July number of the "Bulletin of the International Railway Congress" that the original trial order was followed by an order for a considerable number of engines. The design was at first for a 2 : 12 : 0 class, but the trailing axle was added in order to allow of increasing the capacity of the coal bunker behind the cab. The length of driving wheelbase is 20 ft. 6 in. and special provision is made for lateral movement of the axles on curves. On the sharpest curves this movement may be as much as $1\frac{3}{8}$ in. for the first driving axle, and $3\frac{7}{8}$ to $2\frac{1}{4}$ in. for the truck axles, the latter having radial axle-boxes. All the wheels have flanged tires, but the flanges are smaller than usual on the two middle driving axles.

Water-Waste and Pitometer Surveys in Philadelphia

By John S. Ely*

Although it is only in recent years that systematic efforts have been made to reduce the waste and per capita consumption in the larger American cities by pitometer surveys and otherwise, it is a mistake to suppose that the importance of reducing waste was not fully realized from the earliest years. In 1806, or very soon after the first water mains were laid in Philadelphia, an ordinance was passed prohibiting any person from wilfully causing waste or suffering water to flow for any but necessary purposes, under penalty of $5 fine.

Nearly every annual report of the Bureau of Water for many years past calls attention to the rapidly increasing per capita consumption and useless waste, and the remedy usually advised is the compulsory installation of meters.

This and similar recommendations were almost constantly ignored by the city councils and the prejudice against meters was such that in 1904 an ordinance was passed prohibiting their installation in any premises. This ordinance has since been repealed, but the city seems as far as ever from their compulsory use.

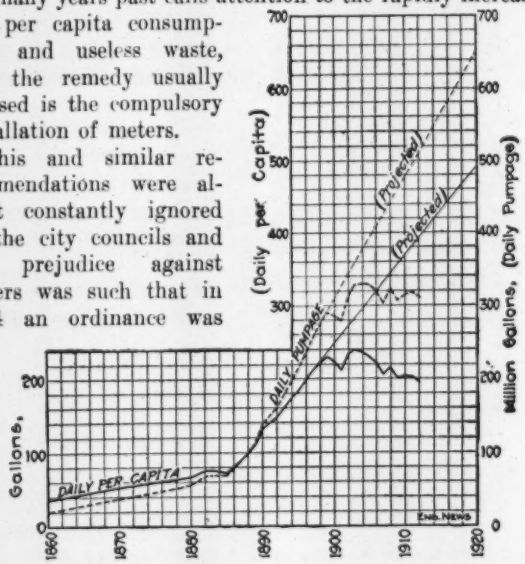


Fig. 1. Water Consumption in Philadelphia, 1860 to 1912, with Projected Consumption for 1898 to 1920, the Latter as Given in Water Bureau Report for 1897

In the annual report for 1897, the then Chief Engineer of the Bureau of Water published in his report a diagram showing the rapidly increasing per capita consumption of water, from which he quite reasonably argued that the consumption in 1910 would be 380 gal. per capita, and in 1920, 490 gal. per capita, unless measures were taken to prevent waste.

It is of some interest to compare the projected line on the diagram with what actually happened [our Fig. 1.—Ed.] and to consider first why the rate increased so uniformly from 1885 to 1899, and secondly, why it then abruptly ceased to increase and has since decreased. The year 1885 marks the beginning of the general introduction of compulsory underdrainage and sewer connections and modern plumbing, and the per capita rate increases regularly as this modern plumbing is introduced and reaches a maximum when it is in almost universal use about 1898 or 1899; and it is to this same modern plumbing that 90% of the waste is due.

The high rate in 1899, however, was partly pumping slippage, and the drop occurring at that time coincides with the installation of new and the abandonment of old pumps.

The present systematic attempt to reduce waste in Philadelphia was begun in April, 1912, by starting a thorough house-to-house inspection for leaking fixtures. Pitometer surveys were begun in August, 1912. The pitometer work during the first year was confined almost entirely to West Philadelphia.

House-to-House Inspection

For convenience in house-to-house inspection, the city was divided into twelve sections, lettered A, B, C, etc., and the blocks in each section were numbered consecutively. Fifty men were employed at $2 per day, with an experienced district inspector as foreman, who laid out the work for his men each morning, assigning a certain block to each man. These inspectors found a great many leaks and the results of their inspection began to be apparent immediately in reduced pumpage.

The corps has since been weeded out and reduced to 30, the pay increased to $2.50 per day, and the men provided with aquaphones and taught how to use them. These latter are invaluable in locating leaks in underground services and yard hydrant pipes. By their use about 1500 such leaking underground pipes have been found.

The aquaphones are also valuable in expediting the work of inspection, for the inspector, by listening on a single spigot, can tell at once whether any water is running in the house, and if there is none, can proceed to the next house, thus saving the time and the inconvenience to the householder of a complete inspection.

The men wear badges and carry cards for identification, and the following general instructions are issued to them:

(1) Inspectors must wear their badges on the outside of their coats in plain sight.

(2) They must at all times be polite and courteous in their manner, and must cause householders as little inconvenience as possible.

(3) They must ask permission of the householder before entering private rooms or bath rooms and avoid doing anything which might be misconstrued on the part of the householder.

(4) They will not waste time over small and trivial leaks. In leaks smaller than ¼-in. stream, it is sufficient to call the tenant's attention to them and no written notice to repair need be made out. It is of much more importance to spend the time in finding large leaks.

(5) They will in all cases carefully examine the service pipe from the street, using an aquaphone, and in cases where there seems to be a leak in the service, it shall be followed up until located and shall be reported to the foreman at the first opportunity.

(6) In cases where leaks are found of ¼-in. stream or more, the regular printed notice to repair will be carefully made out and left with the tenant, the duplicate copy being kept and given later to the foreman.

(7) Inspectors will spend only enough time in each house to walk rapidly through and note the condition of plumbing. Five or ten minutes should be sufficient in all cases.

(8) In cases where leaks of ¼ in. or more are found in rented houses, the name and address of the owner or agent should be taken and written on the duplicate slip.

(9) Inspectors shall keep steadily at work during the whole day and endeavor to find as many large leaks as possible. The city pays you for your time and is entitled to it.

(10) As inspectors are entrusted with discretionary duties, they will be required to display good judgment on all

*Assistant Engineer, Bureau of Water, City Hall, Philadelphia, Penn.

occasions, and lapses from a high standard of conduct will be dealt with accordingly.

A second inspection of those houses where notice to repair has been left, is made about one week later. If the leak is still unrepaired, at the second inspection, a "shut-off" man is sent in a few days and finding the leak still not repaired, he shuts off the water at the curb.

Two clerks keep the records of the inspections and lay out the work for the second inspections and "shutoff" men.

The work of this corps is best shown by a summary for the first six months of 1913, as follows:

Number of buildings inspected	113,808
Number of buildings showing waste (18%)	20,780
Number of buildings repaired	17,371
Number of buildings shut off (many vacant)	2,121
Fixtures repaired, toilet flush tanks	12,432
Fixtures repaired, spigots	6,663
Fixtures repaired, yard hydrants	1,286
Fixtures repaired, horse troughs	36
Fixtures repaired, service and hydrant pipes	2,367

	Cost	Cost per building inspected
Labor	$7908.21	$0.0695
Material	100.40	
Transportation	189.10	
Total	$8197.71	$0.072

The ordinary flush tank of cheap material is responsible for a very large percentage of the total waste. It is often concealed and a good-sized flow may run constantly with very little sound. The very cheap quality of the plumbing and service pipes put into many new houses is certain to cause large leakage sooner or later. A certain standard for such material should be established and qualified plumbing inspectors, representing the Water Bureau, should pass on all new work, just as the Bureau of Building Inspection passes on the thickness of walls and the strength of floor beams, and as the Bureau of Health passes on the underdrainage.

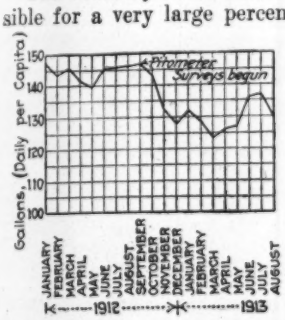


FIG. 2. MONTHLY PER CAPITA WATER CONSUMPTION IN WEST PHILADELPHIA, 1912-13, SHOWING EFFECT OF WATER-WASTE PREVENTION MEASURES

PITOMETER SURVEYS

In August, 1912, the Bureau purchased six Simplex pitometer sets, including recorders. The recorders are of a recently perfected type giving a 24-hr. record of the velocity of flow, in red ink on a circular chart, driven by clockwork. They were first used to check the output from the various pumping stations and filter plants. They are now being used to measure the consumption in various districts of the city, a district being isolated in the usual manner by lines of closed valves and the flow into it measured on one or more large feed mains.

In addition, a number of pitometer rods were purchased for use with a U-tube in making night block surveys. For this purpose the apparatus is set up in a shelter box over a tap in the street main at some convenient point. The adjacent territory is then cut in, a block at a time, by closing the valve at one end and feeding past the pitometer. An observer notes the deflections in the U-tube and the time of each deflection. Thus, the night rate of flow into each block is obtained (the work always being done between 11 p.m. and 5 a.m.). A report of these rates is turned in the following morning and house-to-house inspectors are sent through all the blocks which show a high rate until it is satisfactorily accounted for.

In the six square miles of territory examined in this way, only two leaks have been found in the street mains, these being small joint leaks. In all other cases, the leakage has been accounted for in broken service pipes or house plumbing.

A recent improvement in the method of making these night surveys has been made in the following manner. A short section of 6-in. flange pipe has been mounted on a light covered wagon, the pipe having 3-in. hose connections at either end, and a 1-in. ferrule or pitometer connection in the center. The U-tube is fastened up on the inside of the wagon cover. The block to be examined is shut off at each end, and fed through a fire hydrant from another hydrant on a live block, the wagon being, of course, stationed between the two hydrants, thus measuring any leakage that may exist in the block.

This method has the following advantages:

(1) It permits quicker work because there are fewer valves to handle. The average number of blocks covered in one night is about 20 with the wagon and 15 by the old method.

(2) It is cheaper and does away with the necessity of tapping the main for a pitometer connection.

(3) It can much more readily be taken to any part of the city, where surveys are desired.

It has the disadvantage of being less accurate in measuring the amount of leakage, giving rates about 30% less than the old method, due probably to loss of pressure in passing through the hose. An exact value of the leakage is not, however, necessary in rapid surveys of this character.

These surveys, when followed up by a thorough and efficient corps of house-to-house inspectors, are probably the quickest method of reducing waste in any given territory. It is not necessary for the pitometer corps to stop and examine each house and service individually, but only to find the block night rate. Likewise, it is not necessary for the corps of inspectors to examine those blocks where there has been shown to be no leakage. Each corps, therefore, reduces the work of the other. If at the same time the district in which the work is being done is isolated and the flow into it being measured by recorders, the results of the work can be readily followed. The effects of this work are soon felt in the neighborhood in which it is being done in increased pressures.

RESULTS OBTAINED FROM BOTH METHODS

The net result of the work done so far has been to reduce the rate of consumption in West Philadelphia from 145 gal. to 125 gal. per capita per day, or about 14%.

The total pumpage for the whole city in May, June and July, 1913, averaged 301,638,000 gal. per day, while for the same three months in 1912 it averaged 315,900,000 gal. per day, a saving of 4½%, although only about one-tenth of the area has yet been covered.

Forest Fires which on Sept. 24 were still burning in northern California, have caused damage estimated at $1,000,000. In Napa Co., 600 men are striving to check the flames which have already burned over an area of 90 sq.mi.

Uniform Statistics of Refuse Collection and Disposal

The lack of comparable statistics of refuse collection and disposal is well known to engineers and to city officials who have had occasion to study the subject. As an aid to uniformity and a stimulus to keeping records, a "Standard Form for Statistics of Municipal Refuse" was prepared not long ago by Samuel A. Greeley, of Winnetka, Ill. (*Journ. Am. Pub. Health Assoc.*, Vol. II, No. 2; 289 Fourth Ave., New York City). A preliminary trial of the form was recently made by the Committee on Refuse Collection and Disposal of the Sanitary Engineering Section of the American Public Health Association. The results were given in the report of the committee which was submitted at Colorado Springs, Colo., in the early part of September.

The form, accompanied by a personal letter, was sent to the proper officials in 75 of the larger cities of the United States, with a request that it be filled with statistics for 1912. The "cities were chosen because some members of the committee had a personal association with the official in charge." The result, our readers will agree, was disappointing as to the number and fulness of the replies, but some interesting and valuable figures were obtained from a few cities. Only 8 cities out of the 75 made any reply; only 5 filled out the form; and only 3 filled it completely. The three which did not attempt to fill out the form sent written or printed information of interest.

Notwithstanding this disappointment, the committee considers it worth while and has the courage to say that it will probably make a second trial, next year.*

The information requested on the standard form was grouped under six heads, as follows: A—Statistics of Refuse; B—House Treatment; C—Collection; D—Disposal; E—Miscellaneous. Some of this information we reprint in full, and some we condense without sacrifice of essential facts. The full report, presumably, will be published in *The American Journal of Public Health* within the coming year.

The General Statistics of Refuse (original Table A) are given in full herewith as Table I.

Table B, of the original, deals with refuse cans in New York, Chicago, Milwaukee and Washington. Metal cans are required in each city, covers being specified for Chicago and Washington. The size of cans is reported as 22.5 gal. (maximum) for New York; 5 to 10 gal., Chicago; 10 gal. (average) Milwaukee; and 10 gal. for garbage and 24 gal. for ashes in Washington. Three separations are required in New York and two in Chicago and Washington. The cans are set out for the collectors in all four cities except Milwaukee.

Original Table C—Collection may be summarized as follows: This work is done by the city in New York, Chicago, Milwaukee and Salem; by contract in Washington, and jointly in Boston. As to city ownership of stables and equipment, New York alone answers "Yes." New York City collects both garbage and ashes six times a week in business and residential sections alike, summer and winter, except that in "outlying districts" garbage is collected twice and ashes once a week. Chicago collects garbage and ashes six times a week in the business sections; garbage three times a week in residential sections, ashes three times a week in residential districts in summer and twice a week in winter (so in report); and in the outlying districts both ashes and garbage twice a week in summer and once in winter. Milwaukee gathers garbage not oftener than three times a week anywhere at anytime; and only once in ten days in outlying districts in winter; and it collects ashes monthly, in residential sections only. In Washington, garbage is collected from six to one times a week, according to season and section, and ashes once a week in summer and twice a week in winter, in residential districts only.

The information regarding collection wagons in use and cost of the collection service is reprinted here in full, as Table II.

Under D—Disposal, it appears that reduction is used for the garbage of New York, Chicago, Boston and Washington; incineration for Milwaukee; and in Salem garbage is fed to pigs. Ashes are dumped in all six of the cities just named, but some of them are also incinerated in Milwaukee. Rubbish is dumped in New York (after picking), Chicago, Boston and Salem; incinerated in Milwaukee, and incinerated, dumped and sorted in Washington.

The following additional information on disposal is reprinted in full from the report:

NEW YORK CITY—The cost of disposal of ashes and rubbish is given as 34c. per ton. The reduction plant, located on Barren Island, is an "Arnold" process type of plant and handled 345,900 tons in 1912.

MILWAUKEE—Ashes and rubbish are dumped on about 20 dumps throughout the city. The main dumps are constantly leveled. The cost of disposal is given as 78c. per cu.yd., which apparently includes the collection. At the incinerator, which is of 300 tons daily capacity, 57 men are employed. The gross cost per ton is $1.17. The plant cost $210,000. Steam generated is "being harnessed to run power plant." Clinker is dumped.

WASHINGTON—The area of available dumping grounds is practically unlimited. Public dumps have care takers. The reduction plant is located at Cherry Hill, Va., and utilizes the Chamberlain process. The quantity reduced in 1912 was 48,214 tons. The force employed varies from 75 men in summer to 60 men in winter. The gross cost of operation is estimated to be $2.31 per ton and the revenue per ton is estimated to be $4.20.

There is one plant for burning rubbish with a capacity of 450 cu.yd., located at 26th and Bemings avenues. It consists of a furnace and picking conveyor. Thirty men are

TABLE I. GENERAL STATISTICS OF CITY REFUSE

Unit quantities in pounds

City	Population	Garbage per capita per year	Garbage per 1000 population per day	Ashes per capita per year	Ashes per 1000 population per day	Rubbish per capita per year	Rubbish per 1000 population per day
New York	4,743,773	144	393	1162	3175	89	244
Chicago	2,307,638	103	331				
Boston	686,000	204	656	975	3120	24	77
Milwaukee	392,381	181	497				
Washington	331,069	292	876	579	2259	53	190
Salem	45,000	267	733				

Average weights per cubic yard

City	Garbage	Ashes	Rubbish
New York	1100	1100	133
Chicago	1250		1125
Boston	1350	943	259
Washington	1150	1200	171

Mechanical analyses; percentage by weight

City	Glass	Bones	Paper	Rags	Metals	Straw and wood	Dust	Ashes	Garbage
Chicago Ashes and rubbish	1.9	.05	21.7		3.7	9.0	14.4	32.6	16.2
Washington Ashes	3.0	1.0	9.0	3.0	7.0	2.0	8 9		
Rubbish			96.0	2.0	1.0				

Chemical analyses

Washington, D. C.—Ashes contain 61% carbon and 6% water. Garbage contains 3.75% of grease and 15% of tankage.

*With Mr. Greeley on the committee are Wm. F. Morse and John H. Gregory, New York City, and R. H. Thompson, of Seattle, Wash.

TABLE II. REFUSE COLLECTION WAGONS AND COST OF COLLECTION SERVICE

City	Type of Collection Wagons Used: Garbage	Ashes	Rubbish
New York:			
Capacity, cu.yd.	1.5	1.5	7.5
Material	Steel	Steel	Wood
No. of horses	One	One	One
Attendants per wagon	One	One	One
Covered	With canvas		None
Maker	Sing Sing Prison		
Cost	$123	$123	$123
Chicago:			
Capacity, cu.yd.	4.0	5.0	5.0
Material	Iron	Wood	Wood
No. of horses	Two	Two	Two
Attendants per wagon	Two	One	One
How dumped	Derrick	Hand	Hand
Covered	Iron	Canvas	Canvas
Cost	$225	$172	$172
Milwaukee:			
Capacity, cu.yd.	2.0	3.0	3.0
Material	Iron	Wood	Wood
No. of horses	One	Two	Two
Attendants per wagon	One	One	One
How dumped	Crane	Hand	Hand
Covered	Yes	No	No
Cost	$60		
Washington:			
Capacity, cu.yd.	2.0	3.0-4.0-5.0	8.0
Material	Steel	Wood	Wood
No. of horses	One	Two	One
Attendants per wagon	1 or 2	Two	One
How dumped	Removable bodies	Bottom	Material lifted out
Covered	Steel covers	Canvas	Canvas
Cost	$150	$140-$185	$125

Boston:
Capacity of wagons used, cu.ft.: Single ash carts, 63; double ash carts, 145; paper carts, 167; paper wagons, 288; single garbage wagons, 54; double garbage wagons, 81.

Frequency of washing wagons
New York, Milwaukee, Washington and Salem, daily; Chicago, weekly.

	Number of wagons in service: Summer Garbage	Ashes	Rubbish	Winter Garbage	Ashes	Rubbish
New York	Average number of wagons in service—1469					
Chicago	205	340		150	550	
Milwaukee	106	26		90	125	
Washington	85	30	30	65	75	30

City	Cost of collection per ton: Garbage	Ashes	Rubbish
New York	$0.97	$0.73	$2.46†
Chicago*	3.94	0.639	
Boston	2.99	1.34	$2.71†
Milwaukee*	2.47	0.78	
Washington‡	1.04	0.60	$1.71

* Ashes and rubbish collected together. †Per cu.yd. ‡Includes disposal

employed and 75 women. The plant cost $40,000. The gross cost of operation is estimated at $3.09 per ton, and the revenue at $4.28 per ton.

SALEM—The garbage contract is let for a period of five years for a lump sum of $12,500 at the piggery. One hundred and fifty pigs are kept in the summer and 200 in winter.

The section of the report entitled E—Miscellaneous—relates chiefly to the disposal of stable manure. This material is kept in pits, bins or boxes in the six cities. In New York, it is removed by contract; in Chicago, Milwaukee, Washington and perhaps in Salem, it is removed privately. So far as appears, the manure generally is used for fertilizing purposes.

The International Congress of Refrigeration

The third International Congress of Refrigeration was held at the LaSalle Hotel, Chicago, Sept. 17 to 24. The first congress was held at Paris in 1908, and the second at Vienna, in 1910. The total registration at Chicago (including visitors) was about 650, the foreign delegates and visitors numbering about 150.

These international meetings are held under the auspices of the International Association of Refrigeration, in which 29 countries are represented, while 37 governments pay contributions to assist the work of the Association. These contributions represent 70% of the total receipts. A monthly bulletin is published, in different languages, and is issued from the headquarters at Paris. The report of Emile Gouault, Secretary-General, estimates the revenue for 1913 at $11,200. The report of Mr. Barbet, Managing Director, showed that on July 31, the funds amounted to $9110, while the annual expenses of administration are limited to $4200. There are now 1550 members; and 17 national associations (including the American association) are affiliated with the International Association The President is André Lebon, of Paris (France), who (with the other officers) was re-elected.

For the present congress, the foreign delegates assembled in New York, and (with many of the American delegates) proceeded to Washington, D. C., on Sept. 15. There a meeting was held at the National Museum, an address of welcome on behalf of the U. S. Government being delivered by Hon. William J. Bryan, Secretary of State. Addresses were made also by André Lebon (of Paris), President of the International Association of Refrigeration; Frank W. Gunsaulus, President of the Third Congress of Refrigeration; W. J. Rushton, President of the American Association of Refrigeration; and by several representatives or delegates from Europe, Australia and South America. In the evening a reception was held, at which the U. S. Government was represented again by Hon. Wm. J. Bryan, and also by Hon. David F. Houston, Secretary of Agriculture, and Hon. William C. Redfield, Secretary of Commerce. On Sept. 16, the delegates were received by President Wilson at the White House. The party then started for Chicago, two special trains being provided.

At Chicago, on Wednesday, Sept. 17, the delegates assembled in the council chamber of the City Hall, where an address of welcome on behalf of the city was made by Mr. Sexton, corporation counsel, the mayor being absent. Preliminary meetings of the several sections were held also in different rooms at the hotel. Five sessions were held by most of the sections, and the closing meeting of the Congress as a body was held Sept. 24. In addition to the above meetings, however, there were special meetings of the American Society of Refrigerating Engineers, the American Association of Refrigeration, and several commercial societies dealing with food products and their preservation.

The business proceedings of the Congress were divided among six sections, which held separate but simultaneous meetings. These meetings were generally of very short duration, and in few cases was there any extended discussion of the papers.

Liquified Gases and Standard Units

This section was presided over by Wm. Kent and Prof. D. S. Jacobus, president and vice-president respectively. Two papers on "Latent Heat of the Fusion of Ice," by A. Leduc (Paris) and H. C. Dickinson (Washington, D. C.) reviewed the investigations that have been made with a view to determining fundamental physical constants. Papers by Prof. Kammeringh Onnes (Leyden) dealt with the desirability of new determinations of the thermodynamic properties of the liquefied gases used in the refrigerating industry. A paper by P. Juppont (France) dealt with the standardization of values, units, terms and symbols used in this industry. An attempt was made to have an extra paper presented, giving what its author termed "a simple and positive mathematical refutation of the second law of thermodynamics," but the meeting refused to accept the paper.

Of special interest was a paper on "Liquified Air."

by Prof. G. Claude, the distinguished French scientist. This was accompanied by demonstrations. He referred to the experiments of Tripler in this country, nearly 20 years ago, and explained that these were based on an "entirely excusable" misapprehension of thermodynamics. As the great expectations were not then realized, some discredit was thrown upon the subject in general and has not been entirely dispersed by the later successes. The practical uses of gases from the liquid air (both oxygen and nitrogen) were noted, including the oxygen metal-cutting torch and the Belgian experiments with oxygen in the blast of blast furnaces. Reference was made also to experiments with liquid-air cartridges for blasting, which promise to be of practical value.

He made reference also to the liquefying of the rarer gases existing in the air, and exhibited luminescent tubes containing one of these gases, known as neon. This gas is traversed with peculiar ease by electricity, and the tube gives much greater light with lower potential than the Moore nitrogen tubes. The light is red, however, and has no blue rays. But by combining it with the bluish light of the mercury-vapor tubes a light of normal color is obtained. Prof. Claude reviewed also the research work in physical phenomena at low temperatures, which has been carried on by Prof. Onnes in the cryogenic laboratory at Leyden (Holland). The work is hampered by lack of money, and in response to Prof. Claude's statement several contributions were offered toward the desired fund of $20,000.

Refrigerating Machinery and Insulating Materials

This section was presided over by N. H. Hiller, its vice-president. A new refrigerating process and apparatus, claimed to require much less fuel than other processes, was described by Gardner T. Voorhees (New York). The basis of the saving in fuel is the exhaust-steam absorption machine, and the process is termed the compressed exhaust-steam absorption system. Its introduction is expected to give increased prominence to the absorption system of refrigeration, but the compression system (especially the multiple-effect compression system) may be used in combination with it. Hitherto, exhaust steam from an economical steam plant has been of no value for an absorption system of refrigeration. In another paper, Mr. Voorhees dealt with multiple-effect compressors and receivers. A paper by Edmund Altenkirch (Berlin) reviewed multiple-effect absorption machines, which are used more in the United States than in other countries.

The speed rating of ammonia compressors was discussed by Horace C. Gardner (Chicago), who pointed out the great variations in machines by different makers. He presented the conclusion that long-stroke compressors may be operated at higher piston speed than short-stroke machines, while the latter may be operated at higher rotative speed than the former. In a paper on "The Refrigerating Machine as a Means of Heating," Bernard Tenchkoff (Berlin) described a system for heating buildings where these machines are in use (such as hospitals, office buildings, etc.), and stated that to do this with waste heat originating in the refrigerating machine is more economical than the usual hot-water system with sectional boilers. A combined thermometer and hygrometer for cold-storage rooms (a recent German invention) was described by F. W. Robinson (New York).

The relative economy of oil engines and condensing and noncondensing steam engines was compared in a paper by R. H. Tait and L. C. Nordmeyer (St. Louis) on the first cost and operating cost of an ice-making and cold-storage plant. This showed that the oil engine should be an exceedingly good investment. The paper was discussed at some length in the Congress meeting and also at a meeting of the American Society of Civil Engineers.

Insulating materials and methods were dealt with in papers by R. L. Shipman (Ithaca, N. Y.) and Ernest Rossner (Vienna), while Prof. Moyer described the new thermal laboratory and testing plant at the Pennsylvania State College, which has special facilities for determining the rate of heat transmission of various materials. A paper by J. H. Libberton (Chicago) on "Concrete in Cold-Storage Warehouse Construction" pointed out the advantages of this material and described the special features of some buildings of this type. Concrete construction is cheap, sanitary, vermin-proof, and easily insulated, and has a high fire-protection value. He estimated that a reinforced-concrete building would cost about the same as or up to 10% more than mill construction, and 10 to 20% less than a structural-steel building with fireproofing.

Commercial and Medical Uses of Refrigeration

Two of the sections dealt with the uses of refrigeration in regard to food and the industrial arts. Few of these papers were of technical interest, but one by A. W. Pearse (Australia) showed the enormous growth of the meat export trade of Australia and New Zealand, which has been made possible by the developments of the freezing process both in storage and in transportation. A paper by C. H. Stevens (Brooklyn, N. Y.) showed the value of electric operation of ice-making and refrigerating plants and the importance of such plants as customers of central-station electric companies. A paper on "Pipe Line Refrigeration," by G. F. Bein (Fort Worth, Tex.), dealt with this means of serving hospitals, markets, stores, etc., from a central refrigerating plant, thus avoiding the handling of ice or the installation of small individual ice machines. Both brine and ammonia refrigerating systems have been used in this way. A paper by J. A. Ruddick (Canada) showed that in Canada government subsidies are allowed on public cold-storage warehouses built under certain conditions.

As to the medical and sanitary aspects of refrigeration, a paper by M. E. Pennington and other officials of the U. S. Department of Agriculture dealt with bacterial changes in milk kept at 0° C., while another by L. A. Rogers (of the same department) dealt with the preparation of dried cultures of bacteria. Dr. A. Parker Hitchens, of the Mulford Biological Laboratory (Pennsylvania), had a paper on the relation of refrigeration to the preservation of vaccines, antitoxins and serums. Prof. Bordas (Paris) had a short paper on "Cryotherapy," or the use of local applications of cold in surgical work.

The domestic uses of refrigeration and "The Efficiency of Household Refrigerators" were discussed in a paper by Dr. John R. Williams (Rochester, N. Y.). He showed the importance of keeping food in proper refrigerators rather than in a pantry or cellar, and described

the construction of such refrigerators. In this section also was included a paper on "Ice Formation" by H. T. Barnes (McGill University, Montreal). This dealt with the natural formation of ice on rivers and lakes, and with such special formations as frazil and anchor ice.

Refrigeration in Relation to Transportation

The transportation side of this subject was dealt with in papers on refrigerator cars, replenishing such cars with ice in transit, the handling of ice at railway icing stations, and methods of pre-cooling perishable goods at loading stations.

Some of the papers presented special features of foreign work in this line, including the operation of refrigerator cars over street railways and suburban and interurban lines; also the problems due to through service over lines of different gage of track. For the latter purpose, Mr. Druart (Reims, France) suggested an electric "locomotor" of narrow gage with a low frame carrying a track of standard gage for the main-line car. Mr. Charron (Southern Ry. of France) described a method used for operating through cars over the standard-gage French lines and broad-gage Spanish lines. The car is run to a pit approached by a standard-gage track at one end and a broad-gage track at the other end. The body is lifted off the axles, and journal-box extensions are bolted on (or removed) to fit the axles of the other gage, and the car then shifted along the pit and lowered onto the new set of axles.

The construction of refrigerator cars was described by M. R. Parks (East Rochester, N. Y.), while W. E. Sharp (Armour Car Line) suggested the advantages of a combination heater and refrigerator car. The use of portable stoves to prevent the freezing of perishable goods in winter is dangerous, and gives a very irregular temperature. Several papers by American and French writers, dealt with questions of control and regulation of refrigerator-car service and the distribution of these cars in interstate commerce. The papers suggested an organization to secure proper service and through transfer between distant points.

In regard to transportation by water, C. T. Beck (Hamburg-American Line) had a brief paper on "Refrigeration on Ocean Steamships," while Mr. Roux (Havre, France) described a special vessel used by a French company to transport frozen carcasses from its cattle yards in Senegal to French ports. For local transportation, this company uses refrigerator boxes 7½x6x4 ft., which are loaded at the cold-storage warehouse and shipped on cars or barges. The use of refrigerator barges in New York harbor was described by Walter B. Pollock (New York Central R.R.).

Legislation and Administration

The papers presented at this section discussed laws and regulations affecting the transportation and storage of perishable goods, including laws prohibiting the keeping of goods in cold-storage beyond specified periods of time. Other papers related to damage by sprinkler leakage, and to insurance against indirect damage caused by accidental stoppage of the refrigerating plant, etc. The present status of the refrigerating industry in this and other countries was covered in some of the papers. Three papers dealt with the status of instruction or education in refrigeration, and it appears that very little is being done abroad. A paper by S. S. Van Der Vaart (Chicago) showed that in this country some 70 universities, colleges and technical schools maintain courses in thermo-dynamics or refrigeration, and gave particulars of the equipment and instruction at these institutions.

Entertainments and the Exhibition

The entertainments at Chicago included visits to the stock-yards, packing and other industrial plants, the power plant of the Commonwealth Edison Co., and an automobile trip through the parks and suburbs. There were numerous luncheons and dinners also, including a dinner at which nothing but "cold-storage" viands were served. On Friday, Sept. 19, there was an excursion by special train to Milwaukee, where opportunities were provided for visiting the manufacturing establishments and also the parks. Lunch and dinner were provided and the return to Chicago was made on a night train. Special excursions and entertainments were provided for the ladies in attendance. An illustrated lecture on the Panama Canal was given by Frank G. Lydston; and a lecture on liquified air, accompanied by demonstration, was given by Prof. Claude (of Paris), the noted scientist who has done so much in advancing the development of the production and use of liquified air.

A special feature in connection with the Congress was the Refrigeration Exposition, held in the pavilion at the stock-yards. This was not very extensive, but covered a wide field, including ice-making and refrigerating machinery and appliances, food preservation, cold-storage methods and plant, transportation under refrigeration on steamships and railway cars, and various other matters relating to the general subject. The U. S. Department of Agriculture had a special exhibit of food under refrigeration, one object of which was to interest the housewife and the general public as to the possibilities and advantages of refrigeration in regard to food.

Street Cleaning without Contractors in Washington, D. C.

Street cleaning in Washington, D. C., was done by contract up to July 1, 1911, except that hand patrol work and street washing had previously been conducted by the district authorities on the day-labor plan. Since the date named, all street cleaning has been done by day labor, under the general charge of the Commissioners of the District of Columbia, and under the direct charge of a civil engineer.

Two papers on the municipal street-cleaning work at Washington during the past two years were read before the Sanitary Engineering Section of the American Public Health Association, at its recent Colorado Springs meeting, both written by J. W. Paxton, superintendent of street cleaning, Washington, D. C.* Abstracts of the papers follow.

Cost-Keeping System

It was necessary to make the cost-keeping system conform to general rules governing the district of Columbia. In view of this fact, and in the absence of a model, the cost-keeping system was started along simple lines

*Analysis of "Cost-Keeping as Applied to Municipal Management of Street Cleaning" and "Municipal vs. Contract Street Cleaning."

and changed somewhat as experience was gained. So far as possible, expenses were charged directly under the adopted headings, while other items were "pro-rated according to the easiest methods."

The paper does not so much describe the system of cost-keeping adopted as tell what use has been made of some of its features. Three sets of unit costs are recorded: The first includes all items of expense except foremen and all other overhead charges. The second is this unit plus foremen and general superintendence. The third is the first two plus "a theoretical interest on investment, depreciation, etc." The first set is computed monthly, and the others annually.

On finding, in September, 1911, that the direct-labor costs were lower than contract prices for all kinds of work except alley cleaning (43.3c. per 1000 sq.yd. for municipal, and 40c. for contract work) studies to reduce alley-cleaning costs were made. The use of an alley machine-broom in October cut the cost of alley cleaning by 5½c. per 1000 sq.yd. By eliminating dead travel, and stimulating rivalry between alley gangs, the cost was reduced to 21.8c. for April, 1912. The average for the year 1911-12 was 32.4c. per 1000 yd., or 7.5 below contract cost.

Machine-broom cleaning costs were reduced by changing from a two-sprinkler, five-sweeper combination to one sprinkler working with three sweepers. The contract price for machine sweeping had been 22¾c. per unit. The September figures were from 17.9 to 15c. for the four gangs, the principal difference being that the high gang had two sprinklers and five sweepers, and the low gang one sprinkler to four sweepers. Odometers and cost records showed that a 1-3 combination gave the best results, and it was adopted for the whole city. The average unit cost for the year was brought down to 16.2c., or over 6c. below the contract price, while the minimum cost in April, 1912, was only 12.2c.

An interesting example of saving attained in another way was the use of new sheet leather instead of scrap for making washers for use with small wire nails for attaching strips to the drums of the squeegee brooms. Labor here was the chief item, so it was cheaper to throw away the scrap leather, and buy good leather, than to save the scrap. But still further investigation showed that the leather could be dispensed with, and a galvanized nail, with a large head, be used instead of a washer and nail. The first change cut the cost of attachment from $3 to $2 and the second to only 60c.

Good results have been attained by means of profiles or curves showing the comparative cost of the same class of work as done by different gangs. Thus, stable efficiences are compared by plotting percentages of all horses fit to work. In October, the average efficiency of all stables was only 90%, and instead of increasing with cooler weather it fell as low as 86%. Conferences between the foremen of high- and low-efficiency stables, and the stimulation of the continued use of the profiles, raised the combined stable-efficiency curve until sometimes it reached 100, "averaging about 98% to date." The significance of these changes is the better appreciated when it is remembered that every horse out of service means a loss of about a dollar a day "for keep."

The concluding portion of Mr. Paxton's paper on "Cost Keeping" deserves printing in full, with special attention called to the words of caution in the last two paragraphs:

It is impossible to show, without a mass of detail, involving blank forms, tables, etc., the innumerable ways the cost-keeping system, directly or through data compiled as a result of cost-keeping methods, has increased efficiency. Changes are being made daily and errors in judgment on the part of foremen or higher officials are found, at first very often, but as a result of the education due to the study of such errors, only occasionally at present.

The principal advantages of such a system may be summarized as follows:

(1) Gives the detailed cost for each gang, for each class of work or for any particular feature which may be under investigation, in such form as to admit of analysis of any variation in previous costs or comparison between similar details of other work, as well as showing the result in any change of method.

(2) Provides a means of determining the relative efficiency of foremen or laborers and provides a tangible record for educational purposes, giving in money the effect of any internal change in the make-up of a gang and means of competitive comparison between gangs.

(3) Gives records of intermediate costs, such as stable, repair-shop or office expense, in which the greatest possibility of saving lies, in terms which admit of comparison with other departments or firms as well as internal comparison between two units, such as two stables of the same department.

(4) Gives repair costs, which in time, will give comparison as to the relative efficiency of two similar pieces of apparatus of different manufacture as well as a check on excessive repairs, etc.

These represent probably the most important uses of the system as developed at present. New applications are constantly coming up to create fresh interest and to keep the system alive. Often some new item will creep into a standard report, be investigated and result in a new train of thought and study, with increased efficiency and renewed interest, not only in the new feature but necessarily in the routine which is required to develop the working figures.

In closing, a word of caution. The local system has been in operation about two years. During that time many changes have been made, not in principle, but in detail, and it is expected that others will be necessary. The Washington system, as a whole, will probably fit no other department in Washington nor the Street Cleaning Department of any other city. Cost keeping is necessarily a process of first, evolution, and second, elimination. This department has gone through the first and the question now is can we do without this detail or how can we obtain it with less effort?

The experience here has been that the best way to obtain satisfactory cost-keeping data is to go slowly. Not to hire an expert for two weeks or two months to develop a system but to put someone in charge of the cost development, have him read, study and investigate other systems and then develop that system best fitted to the particular needs of the work and educate the force to a proper understanding of the results obtained.

Municipal vs. Contract-Street Cleaning

Even under the handicaps of the first year of the direct-labor system at Washington the average costs were less than the contract prices. The second year, ending June 30, 1913, showed that with the same amount of money, over 25% more work had been done by the municipal than by the contract system. The greater part of Mr. Paxton's second paper follows:

Unfortunately, the quality of the work, being a matter of observation and judgment, cannot be shown in figures, but the whole interest of the municipal authorities in charge of street cleaning is to have the work well done, while the object of the contractor was to do it well enough to be paid. The stock is largely supplied by horses from the Fire and Police Departments, which have become unfit for fast work, but are splendidly able to do the work of street cleaning and were originally the best that could be bought. They are kept better and fed better than the contractor's horses. All equipment is kept in perfect condition. The men are well paid, work hard, are employed and discharged according to their ability to work only; and thoroughness at all times is insisted on. There seems to be no reason then for the efficiency being less, and the testimony of old employees of the department and impartial citizens, who have been sufficiently interested to observe, is that the streets are in better condition now than they have ever been before.

There are a few general principles which led the authorities in Washington to believe that street cleaning could be done more economically and efficiently by the municipality direct than by contract. They have been proved to be correct by actual experience and being applicable to street cleaning in other cities, the following effort to set them forth may be of interest.

Contractors exist only because they have special knowledge and equipment for doing certain work, acquired through the regular practice of doing similar work, while the other party to the contract is otherwise regularly engaged and only occasionally desires work done which the contractor makes a specialty of.

Apparently this condition does not apply to street cleaning. The work is done every day, year in and year out. There is no question about the municipality being able to finance the operation or purchase the necessary equipment, property, etc. It should be possible to develop and educate the organization far ahead of that of any contractor, especially if the terms of the contracts are short and there is enough competition to make changes in contractors probable.

This being almost entirely a labor contract, it would not be unusual for a contractor to figure 20% profit, which is more liable to be increased than diminished through insufficient, careless, ignorant or dishonest inspection.

Street cleaning is probably the most difficult work to inspect of any which could be let under contract. No street is ever perfectly clean, only relatively so, depending on the accumulation of dirt and the amount of efficient cleaning. It is impracticable to specify that the contractor shall furnish clean streets or even clean streets at certain periods, but each detail of the required operation of street cleaning must be specified, inspected to see that each detail is carried out, and the city then must be satisfied with results. In order to obtain efficient inspection in Washington under the contract system, it was found necessary, in addition to general supervision, accounting, etc., to have an inspector with each gang of cleaners.

Under contract, the necessity for the study of this problem is not usually fully realized by the municipal authorities, and they are invariably not prepared to specify in detail the work which is to be required of the contractor. Sufficient opportunity for experiment and observation is not afforded and therefore improvements are not often discovered. Even if improvements are discovered, changes are difficult, if not impossible, and resulting economy would benefit the contractor and not the city.

On the other hand, when the municipal authorities are directly responsible for the work, it is up to them to make good. All the details intrude themselves on their notice, changes can be made immediately and the city at once receives the benefit.

For example, under the contract system in Washington changes occurred very slowly and usually only when specifications were made up for new contracts, once in five years, but in the municipal work of the last two years, improvements have been of daily occurrence. Each blockman's work has been studied individually. Time studies with odometers have been made of all vehicular movement. Collections are all made working toward the dumps. Schedules are arranged for all machines, squeegees, flushers, etc., so as to do effective work every moment from the time they leave the stable until their return. Each gang is arranged so as to have the number of sprinklers, machines, broomers, shovelers, carts, etc., in proper proportion. It has been found that some of the wider alleys can be swept to advantage with one-horse brooms, and schedules have been very carefully arranged so as little time will be lost as possible in going from one alley to another. The area of each square, intersection and alley has been carefully computed and card-indexed, and a cost-keeping system has been established so comparisons can be made of the cost of cleaning per thousand square yards, each month or oftener, with the similar costs in previous months, or one foreman's work with another doing similar work, or one method of cleaning with another. The office is supplied with a multigraph printing machine so that schedules may be changed and reprinted on a day's notice.

The most radical change in methods has been to increase the hand cleaning combined with an occasional washing and decrease the machine-broom areas. The machine brooms raise so much dust that heavy sprinkling is required, the fine dust mixes with the water into a fine mud, which is smeared on the street by the broom, and when this becomes dry, it turns to dust again. The brooms only sweep the coarser particles and many of these are thrown over the broom, by centrifugal force, back to the pavement again.

Hand-cleaning work is capable of better distribution than any other method, more attention being given to the dirtier areas by simply increasing the number of men, who only clean the portions of the street which are dirty and work on these portions until they are clean. There is a fine scum which becomes plastered to the pavements, particularly sheet asphalt, which is not apparent when the pavements are dry, but rises up in a thin sheet of mud when moist, making the pavements very slippery. This and fine dust cannot be removed by the hand cleaners; but by washing about twice per week, in addition to hand cleaning, these troubles can be eliminated.

Lastly, but not so important, are the contractors' risks, particularly in lump-sum contracts, which the city must pay for, due to the possibility of increasing and shifting business and population, but principally on account of unusual seasons or weather.

NOTES

A Derailed Train Was Hit by an express on another track, on the Great Northern Ry., near Mukilteo, Wash., Sept. 22, resulting in injuries to 11 persons.

A Speed of 125¼ Mi. per Hr. was made by Maurice Prevost, the French aviator, in the first half (62 mi.) of the race at Rheims, France, Sept. 29, for the International Aëroplane Cup.

A Brick Chimney Collapsed at the Deering plant of the International Harvester Co., Chicago, during a storm on Sept. 29. One man was killed and several were more or less injured by the falling wreckage.

A Two-Ton Casting Fell at the Canadian General Electric works, Peterboro, Ont., Sept. 20, while being moved by a crane, and killed a man who was directing its motion from beneath. The accident was caused by the failure of the fastening of the hook and pulley of the crane.

The Fall of a Steel Chimney, 180 ft. high by 18 ft. 6 in. in diameter, across the fish-plate mill at the Moss Bay Works of the Workington Iron & Steel Co., Workington, England, Sept. 16, killed five men and injured about 12 others. In falling, the stack broke the exhaust header of the power plant of the company, and buried the rolling mill beneath the wreckage of steelwork and corrugated iron roofing brought down in the fall. The cause of the accident is unknown.

A Peculiar Gas Explosion blew out seven windows and damaged the concrete floor and the roof of the engine room of the furniture plant of the C. Streit Mfg. Co., Cincinnati, Ohio, Sept. 22. The gas engines exhaust in a common pit, which has a vent to the air by means of a pipe to the roof. According to press dispatches gas entering through the drainage connection is believed to have accumulated in this pit between Saturday and Monday and to have been exploded by an electric spark, when the engines were started.

Two Street Cave-ins Occurred in Greater New York, which resulted in the death of three men. The first was in East New York, Brooklyn, where a cellar was being excavated. It is stated that 10 tons of earth, including a 2000-lb. rock, fell upon three men who were at work in the excavation, killing two. The other accident was at Lexington Ave., and 26th St., New York City, where a conduit is being constructed by the Consolidated Telegraph & Electric Subway Co. Workmen were tunneling from a manhole and had made their way to a point under the Lexington Ave. trolley tracks when the timber shoring collapsed and a section of concrete six feet square fell upon and killed one of the men.

PERSONALS

Mr. Joseph W. Hunter, M. Am. Soc. C. E., was recently designated as Deputy Highway Commissioner in charge of the new bureau of Township Highways, of the State of Pennsylvania.

Mr. L. A. Harding, who from 1909-12 was in charge of the department of mechanical engineering at the Pennsylvania State College, has been appointed Professor of Experimental Engineering at the University of Illinois.

Mr. Herbert A. Walker, M. Inst. C. E., General Manager of the London Southern Ry., England, is visiting the United States at the present time. Mr. Walker was the guest of the Massachusetts Public Service Commission on Sept. 22.

Mr. J. I. Parcel, and Mr. W. M. Wilson have been appointed Assistant Professors of Structural Engineering at the University of Illinois. Mr. Parcel was formerly Assistant Pro-

fessor in this subject at the University of Minnesota. Mr. Wilson since 1912 has been Chief Designer with the Strauss Bascule Bridge Co., Chicago, Ill.

Mr. L. H. Provine, formerly with the Stone & Webster Engineering Corporation in charge of their office at Los Angeles, Calif., has been appointed Professor of Architectural Engineering at the University of Illinois. Mr. Provine was graduated from this institution in 1903 and, during 1908-9, was instructor in architectural engineering there. Since 1909 he has been with Stone & Webster.

Professor S. Tanabe, who holds the chair of civil engineering at the Kyoto Imperial University, Japan, is visiting the United States to study recent American engineering works. This is the third visit Professor Tanabe has paid to the United States, having first come to this country 26 years ago to examine some American hydraulic works. A portrait of Professor Tanabe with some account of his important work in Japanese engineering was published in our issue of Oct. 17, 1912.

Mr. Herman W. Reynolds has been engaged by the United States Government to establish a department of mechanical engineering at the University of the Philippines in Manila, P. I., and will occupy the chair of mechanical engineering in the University. Prof. Reynolds was for eight years professor of mechanical engineering at the University of California, and has been associated for the past year with Chas. C. Moore & Co., of San Francisco. Prof. Reynolds some time ago spent a couple of years in China in the employ of the Chinese Government.

Dr. Walter Bensel, Sanitary Superintendent of the Board of Health, New York City, will retire from his office on Oct. 1, after 20 years' service. Dr. Bensel was graduated from Columbia University in 1887 and five years later entered the Health department of this city as an inspector. When the garbage strike endangered the health of the city, Dr. Bensel temporarily became Commissioner of Street Cleaning. His brother, John A. Bensel, is the present State Engineer of New York, and was Dock Commissioner for this city under the administration of Mayor McClellan.

OBITUARY

Mr. Wm. W. Gamwell, President of the Stanley Electric Co., died at Sheboygan, Wis., Sept. 21. Mr. Gamwell was born in 1850.

James Smith, at one time General Traffic Manager of the Wabash R.R., and well known in railroad circles, died recently, at his home in Fort Wayne, Ind., at the age of 77 years.

Dr. Joshua Hering, until lately a member of the Maryland Public Service Commission, died recently at Baltimore, Md. Dr. Hering was formerly State Controller of Maryland, and was born in 1833.

William F. Ray, General Superintendent of the Boston & Maine R.R., died suddenly at Boston, Mass., Sept. 26, at the age of 56 years. Mr. Ray began his railroad career with this company 30 years ago, in the capacity of a fireman.

Mr. F. P. Catchings, Assoc. Am. Inst. E. E., of the electrical department of the Alabama Power Co., Birmingham, Ala., was drowned in the St. John's River, Sept. 22, while on a vacation. Mr. Catchings was assistant to the chief electrical engineer.

William Corey Selden, a consulting engineer, died at his home in Brooklyn, N. Y., Sept. 24, at the age of 81 years. Mr. Selden entered the U. S. Navy as a third assistant engineer in 1859, became second assistant in 1861, and first assistant in 1863, resigning from the Navy in 1868. He was actively engaged in his profession until 1912.

William Armstrong Ingham, M. Am. Inst. M. E., President of the Rock Hill Iron & Coal Co., died at his home in Philadelphia, Penn., after a brief illness, Sept. 23, at the age of 87 years. Mr. Ingham was graduated from Rensselaer Polytechnic Institute in 1846. He was admitted to the bar in Philadelphia County in 1855. Since then he has held many executive positions and was engaged in active business up to the time of his death.

Michel M. Le Brun, a prominent architect of New York City, died at his home in Montclair, N. J., on Sept. 27. Mr. Le Brun was a son of the late Napoleon Le Brun, also prominent as an architect. Mr. Le Brun's most notable architectural work was the white marble building of the Metropolitan Life Insurance Co., on Madison Square, New York City, the high tower of which was, at the time of its construction, the most lofty building in the world.

Arthur L. Adams, M. Am. Soc. C. E., a consulting hydraulic engineer of San Francisco, Calif., died at his home in Oakland, Sept. 17, at the age of 49 years. Mr. Adams was born in Greensberg, Ind., and was educated at the University of Kansas. After a brief experience in railroading, Mr. Adams became City Engineer of Pendleton, Ore. From 1894-1[illegible] his activities were in the field of hydraulics. In the latter year he opened an office in San Francisco as consulting hydraulic engineer.

Major-General George Lewis Gillespie, formerly Chief of Army Engineers, died at his summer home in Saratoga, N. Y., Sept. 27. Gen. Gillespie was born in Kingston, Tenn., on Oct. 7, 1841. He was graduated from West Point in 1[illegible] and served the Union in the Engineers Corps of the Army of the Potomac during the Civil War. In 1895 he was appointed a member of the Mississippi River Commission. In January, 1904, he attained to the rank of Major-General and was retired on June 17, of the following year.

Mr. John Douglas Fouquet, M. Am. Soc. C. E., died at his home in Fishkill, N. Y., Sept. 18, at the age of 84, after an illness of one month. Mr. Fouquet was born in Plattsburg, N. Y., Aug. 1, 1829. He entered the Rensselaer Polytechnic Institute, in 1849, but after three years of study left college to become a draftsman with the Plattsburg & Caughnawauga R.R. (now a part of the Delaware & Hudson R.R.). After a varied experience in engineering work, principally on railway construction, Mr. Fouquet in 1866 became Chief of Topography on the staff of Col. Jas. Worrell, Chief Engineer of the Sir Morton Peto project for an air line railroad between New York City and Chicago. This work consisted largely in bridging the gaps between existing railroads in New York, Pennsylvania and Ohio, and was abandoned in 1867 through the failure of Sir Morton. Mr. Fouquet then became successively: Division Engineer, and later Architect of what is now the Central New England R.R.; Engineer and Architect with Garner & Co., of New York City, owners of 11 cotton mills; in charge of the building construction of the West Shore Ry., and one year later Division Engineer (1883-6). When the New York Central R.R. leased the West Shore Ry., Mr. Fouquet was appointed Architect of the system (1886-1893). His last active work was in connection with the New York Central R.R., from which he retired in 1905. Mr. Fouquet leaves two sons: The elder, L. D. Fouquet, is at present Engineer, Sewer Division, Public Service Commission, First District; the younger, M. L. Fouquet, is Engineer of Substructures, Borough of Brooklyn, N. Y.

ENGINEERING SOCIETIES

COMING MEETINGS

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Oct. 7-10. Annual convention at Wilmington, Del. Secy., Geo. H. McGovern, Chamber of Commerce, Wilmington, Del.

RAILWAY SIGNAL ASSOCIATION.
Oct. 14-16. Annual meeting at Nashville, Tenn. Secy., C. C. Rosenberg, Times Building, Bethlehem, Penn.

AMERICAN ELECTRIC RAILWAY ASSOCIATION.
Oct. 13-17. Annual convention at Atlantic City, N. J. Secy., H. C. Donecker, 29 West 39th St., New York City.

AMERICAN GAS INSTITUTE.
Oct. 15-17. Annual meeting at Richmond, Va. Secy., Geo. G. Ramsdell, 29 West 39th St., New York City.

NATIONAL SOCIETY FOR PROMOTION OF INDUSTRIAL EDUCATION.
Oct. 19-25. Annual convention at Grand Rapids, Mich. Secy., C. A. Prosser, 105 E. 22d St., New York City.

AMERICAN MINING CONGRESS.
Oct. 20-25. Annual convention at Philadelphia, Penn. Secy., J. Callbreath, Majestic Building, Denver, Colo.

AMERICAN RAILWAY BRIDGE AND BUILDING ASSOCIATION.
Oct. 21-23. Annual convention at Montreal, Que. Secy., C. A. Lichty, 319 North Waller Ave., Chicago, Ill.

NATIONAL ASSOCIATION OF RAILWAY COMMISSIONERS.
Oct. 28. Annual Convention at Washington, D. C. Secy., Wm. H. Connolly, Interstate Commerce Commission, Washington, D. C.

NATIONAL CONSERVATION CONGRESS.
Nov. 18-20. Annual meeting at Washington, D. C. Secy., T. R. Shipp, Indianapolis, Ind.

GREAT LAKES INTERNATIONAL PURE WATER ASSOCIATION.
Nov. 6-7. Meeting at Toronto, Ont. Secy., Paul Hansen, Urbana, Ill.

UNITED STATES GOOD ROADS ASSOCIATION.
Nov. 10-16. Third annual meeting at St. Louis, Mo. Secy., J. M. Rountree, Birmingham, Ala.

NATIONAL FOUNDERS ASSOCIATION.
Nov. 19-20. Annual convention at New York City. Secy., J. M. Taylor, 29 So. La Salle St., Chicago, Ill.